JB July 5/55

C. C. James, Dec 23/97

THE
PROCEEDINGS AND TRANSACTIONS
OF THE
Nova Scotian Institute of Science,
HALIFAX, NOVA SCOTIA.

SESSION OF 1896-97.

VOLUME IX

(BEING VOLUME II OF THE SECOND SERIES)

PART 3.

The First Series consisted of the Seven Volumes of the Proceedings and Transactions of the Nova Scotian Institute of Natural Science.

PRICE TO NON-MEMBERS: ONE HALF-DOLLAR.

HALIFAX:
PRINTED FOR THE INSTITUTE BY THE NOVA SCOTIA PRINTING COMPANY.
Date of Publication: November 30th, 1897.

CONTENTS.

PAGE

PROCEEDINGS, SESSION OF 1896-97 :—

Opening Address by E. Gilpin, Esq., Jr., LL. D., President :—
Review of Session's Work lxxix
The System of Instruction and Examination of Mining Officials in Nova Scotia lxxxi
Report of the Librarian lxxxvi
Office-Bearers for 1896-97 lxxxvi
Measurements of two Beothuk Skulls, by W. H Prest, Esq lxxxviii
Resolution on Proposed Victoria Research Fund................. xci
Calcareous Algae, by A. H. MacKay, Esq., LL. D.......... xcii

TRANSACTIONS, SESSION OF 1896-97 :—

I. On the Relation of the Physical Properties of Aqueous Solutions to their State of Ionization, by Prof. J. G. MacGregor..... 219
II. On some Analyses of Nova Scotia Coals and other Minerals, by E. Gilpin, Esq., Jr., LL. D 246
III. Notes on Nova Scotian Zoology, No 4, by Harry Piers, Esq.... 255
IV. Phenological Observations, Canada, 1896 compiled by A. H. MacKay, LL. D.......... 268
V. Supplementary Note on Venus, by A. Cameron, Esq.. 275
VI. The Rainfall in 1896, by F. W. W. Doane M Can Soc. C. E. . 279

APPENDIX—III. :—

List of Members, 1896-97.............. IX

MEMBERS of the Institute, and Societies in correspondence with it, would confer a great favor if they would send to the Council, for distribution to Scientific Institutions whose sets of the Institute's publications are incomplete, any duplicate or other spare copies which they may possess of back numbers of its Proceedings and Transactions. They should be addressed *The Secretary of the N. S. Institute of Science, Halifax, Nova Scotia.*

THE attention of members of the Institute is directed to the following recommendations of the Committee of the British Association on Zoological Bibliography and Publication :—

"That author's separate copies should not be distributed privately before the paper has been published in the regular manner

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules for quotation, such as that recently adopted by the French Zoological Society."

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1896-7.

ANNUAL BUSINESS MEETING.

Legislative Council Chamber, Halifax, 9th November, 1896.

The PRESIDENT, DR. GILPIN, in the chair.

The PRESIDENT addressed the Institute as follows :—

GENTLEMEN,—I have much pleasure in meeting you to-night. I present myself your representative to mark the close of another year of the existence of the Institute, and to inaugurate a new session.

In one sense, I may claim to be numbered among the oldest of those who have been interested in this Society. Although it is nearly a quarter of a century since I was allowed to read my first paper before you, there are a number of you who have been for a much longer period members.

I remember, however, being present and watching as a boy the initiatory meeting of the Institute, being the more interested as the late Dr. Gilpin, who read the first paper in our proceedings, took an active part. Almost all the original members have now ceased from work, but their record remains.

From its commencement, the Institute members have ranged over all the fields of science open to observers in this Province, and have recorded their opinions and deductions according to the lights of their days. Their arguments may now be displaced or amended in the focus of the science of to-day or to-morrow; the facts they have accumulated remain, and we may feel satisfied if we have contributed our quota of bricks to the daily increasing foundation of the sciences.

In every division of nature our deductions and laws remain good until rendered untenable by the unanswerable chill of fresh facts. The true student rejoices at the demolition of his fabric when he knows that the opportunity is offered of modelling it on a broader and surer foundation.

It is largely in the accumulation of facts that a useful future lies before us, and I would impress upon you the desirability of enrolling every person who can give careful and accurate observations upon the natural world surrounding us.

One discovery by one of our members of an important fact bearing on the protection of our agricultural products from the attacks of noxious insects, the introduction of a form of animal or vegetable life capable of anchorage here, and serving to our needs, or any similar discovery, would many times repay the money we have spent. We should have on our list every person willing to study in these or kindred branches, and to such substantial assistance should, I think, not be denied by you.

The transactions of the past session of the Institute will, I think, be considered, to say the least, quite up to the mark. Of most general interest will be found the portrait of our late friend, Dr. Lawson, and Prof. MacGregor's sketch of his busy and useful life. In addition to the regular papers, matters of interest were submitted at various meetings by Prof. MacGregor, Drs. MacKay and Somers. At a special meeting the Rev. G. Patterson read a valuable paper on "Newfoundland Folk Speech."

In the Transactions are two linked papers by Prof. MacGregor and D. McIntosh on the calculation of the conductivity of mixtures of electrolytes. The former showed by a graphical process, based on observations, the calculability of the conductivity of a series of mixtures of solutions of chloride of sodium and potassium. He found that the calculations agreed with the observations in dilute solutions, but not in stronger ones. The latter extended the observations in order to determine the differences between the observed and calculated values in the case of the stronger solutions, and the extent of agreement in the case of solutions of sodium chloride and hydrochloric acid which have ionic velocities differing more widely.

Among the geological papers is one on the unexplored coal fields of Nova Scotia by me, and an interesting note by Mr. T. C. Weston on a few new paleontological facts, and on the general similarity of the fossil faunas of the silurian of Canada and Newfoundland. Mr. Prest, in a paper on Glacial Succession in Lunenburg County, differs somewhat from the conclusions arrived at by the Geological Survey. Professors Bailey and Coldwell have referred in two papers to the Superficial Geology of Kings and Queens Counties, the former referring also to interesting exhibits of faulting, metamorphism, vein filling, contacts, etc. Dr. Somers has contributed a note on Juniperus Communis, from which it appears that instead of one variety, the most common, decumbent, being only found here, there is another less common having a shrubby form. I am pleased to be able to inform you that the Doctor has promised further contributions on botanical subjects.

Dr. MacKay has continued his important summaries of the reports of phenological observations made under the auspices of the Botanical Club of Canada.

The Transactions close with an interesting paper by Mr. Piers, our Recording Secretary, on the Orthoptera of Nova Scotia. I understand that he proposes to extend this paper, which embraces a study of much value to our agriculturists.

I think that it is now in order for me to thank you for your kindly consideration of the office of President during the past year. I feel that a good Council and a faithful staff of officers have combined not only to make his path easy, but to maintain and promote the progress of the Institute. To the Treasurer, the Librarian, and to the Secretaries, the thanks of the Institute are justly due. Having done so little myself, I can the more fairly estimate the value of their labors, and can honestly say, I believe, that if the members would treble their numbers they would so much the more willingly discharge their increased tasks.

It has occurred to me that a few remarks on the system of instruction and examination of mining officials instituted by the Government of this Province, may be of interest.

The Institute proceedings contain many papers upon geological and allied subjects, and any efforts tending to increase the observing and recording powers of those directing our mining operations cannot fail to be appreciated by you.

Wherever communities are engaged in a particular occupation, a certain average level of intelligence prevails. This standard never sinks below that essential to the earning of the wage paid, but it is with difficulty raised. The prominence of individuals due to their greater physical strength, or to the more practical application of their mental power to the subject of their work, excites envy rather than emulation. In such communities the first step upward is resistance against encroachments by the employer. Unions follow. In many cases this coalition of labor has no aims beyond the preservation of wages against reduction, and their increase at every opportunity. In some instances attempts have been made at boards of conciliation and arbitration, and sliding scales. These aspirations, however, are but the outcome of that experience of unionism which has shown that facts and natural laws must be considered, and may be called a selfish extension of the original scheme.

In Nova Scotia, the most powerful labor union is perhaps that of the coal miners. Its organization has given occasion for a conciliation and arbitration act, which promises well, altho' it has not yet undergone the ordeal of practical application. The outcome, however, of this organization, more interesting and ultimately useful, is that relating to education.

It was recognized by those who were mainly interested in the objects of the Provincial Workman's Association, and especially by the Hon. R. Drummond, the Grand Secretary, that the proper conduct of the business of the various lodges, the proper estimation of the social problems of politics, supply and demand, etc., thus suddenly presented, and the intelligent discussion of the labor and mining problems most directly affecting them, required that the intelligence and education of the members should be materially assisted. It soon became apparent that the better the members understood the problems of the miners' occupation the less liable were the different unions to be hurried passionately into ill-advised and half-considered conflicts with capital. It was also evident that the better the status of the subordinate officials about the mines the more the safety of the miners was secured. After some discussion it was agreed that the experiment should be tried of fixing a standard for underground managers and overmen. The necessary statutory power having been granted by the government, an order-in-council appointed a Board of Examiners tentatively. As experience was gained, changes were made until the present system, which has worked satisfactorily for some time, was established.

The Province, for the purpose of the Board, has been divided into three districts—Cumberland, Pictou, and Cape Breton. From each of these districts are appointed two men representing respectively the companies and the workmen, and a third, as far as possible, a mining engineer not interested in the operations of any company. The Inspector of Mines acts as Secretary and the representative of the Government on the Board. The questions are prepared by the Board at a full meeting; the examinations held simultaneously by the local divisions of the Board; and the answers considered at a full meeting of the Board.

It was soon found that many candidates were deficient in surveying and the knowledge of arithmetic, logarithms, geometry, etc., necessary for the solution of the problems of ventilation, etc. The most intelligent of the successful candidates, in many cases men who had unaided made themselves masters of these subjects, were appointed instructors for the candidates. In this way an annual course, some months in length, has been established at the principal collieries, about ten instructors being employed. The expenses of these schools are met by the Mines Department, and each teacher receives a fixed fee, contingent upon his presenting at least two candidates, in addition to a fee for each candidate that passes a successful examination.

The first certificate of competency was issued March 15th, 1883, and since that date 121 certificates have been issued to underground managers, 146 certificates to overmen, in addition to 32 certificates of service to those holding these positions at the time the law came into force. This system has established an ample supply of men for our own collieries, and those leaving our shores find their certificates a good passport to respectable positions abroad. The conditions of admission for a candidate are that he be at least twenty-one years of age, of good reputation, and have been employed at least five years underground. The readiness and precision of the answers of many of the candidates would do credit to examinations of a much more pretentious character.

It was finally decided that the provisions of the act should be extended to mine managers, and the powers of the Board were amplified. In all 41 certificates have been issued to managers. Quite a number of those holding manager's certificates are working miners who have successively passed the different examinations, one after the other, with intervals required to attain the additional knowledge. In one instance a foreigner, unable to speak or write in the English language when he arrived a few years ago, has passed, not without failures, until he has been appointed a manager of a coal mine. This instance, perhaps the most extreme, illustrates the fact that the advantages offered by this scanty system of education are well received by the more ambitious and intelligent of our miners. In the end the lodges at the different collieries have profited as well as the mines, for I am informed no small percentage of their officials and leading men are holders of certificates. The fact that the miners recognize the fitness of such men to be their guides and advisors is a strong argument that moderation and wisdom will mark their deliberations.

As you know, at nearly all of our coal mines the men are raised from and lowered to the scene of their work by machinery. The drivers of these engines are always selected with much care, as they require to be reliable and steady men. It was decided that, in order to increase the margin of safety, these men should undergo examination as to their knowledge of boilers, machinery, etc. A Board of three mechanical engineers was appointed representing, as in the case of the Board I have already referred to, the three principal coal districts. The examinations are conducted in a similar manner, and already 74 certificates have been issued, including those certificates of service granted those engineers found worthily filling their positions at the time the law was passed. Whenever a class of candidates offers, mechanical instructors are appointed on the principle described already.

I may mention that the work of the instructors and boards has been facilitated by the provision made by law for the establishment of night schools in mining and other districts. Many candidates, as might be expected, however good their practical knowledge and experience may be, are deficient in the exact grounding required for examination. They can remedy this by attending the night schools, and the mining instructors are thus relieved of much drudgery and able to teach the essentially mining subjects with greater detail.

As is well known, the strength of a chain is precisely that of the weakest of the links composing it. In mining, however careful the overmen and watchmen may be, one ignorant or careless workman may nullify all their efforts and precautions, and in a moment lose his own or another's life, cause an explosion, or a fire. In order, therefore, that there might as far as possible be no lack of endeavor to make all safe, it was determined that the miners themselves should be examined as to their practical experience and knowledge. This has been carried out, and I believe there is not a coal miner working to-day, except perhaps in a few mines open only a few months in the winter, who is not the holder of a certificate. After a certain period of employment under ground as loader, driver, etc., he is permitted to assist in cutting coal. The miner, however, in charge of the place in which he works and assists, is the holder of a superior certificate secured by examination. These examinations and the issue of certificates is effected through local boards appointed at each colliery and paid by a small fee.

These boards also examine applicants for the position of shot firers. These are men who are, under certain conditions of the mines, appointed to supervise the firing of the charges of gunpowder or other explosive used in blasting the coal. I may say these examinations of miners and shot firers are *vivâ voce*, all the others being by written answers.

While the business connected with these examinations has added materially to the work of the Inspector of Mines, it is a satisfaction to know that the results so far have been encouraging. The standard exacted from the candidates compares well with that required in other countries. The Government and people of Nova Scotia may feel pleased that in this respect we have gone ahead of other countries, and have made a successful attempt to place within the reach of every coal miner in the Province the means of his advance to a state of education, and an opportunity of fitting himself for responsible and respectable positions.

While explosives are permitted in coal mines, and while work is necessary in dangerous atmospheres with lamps liable to accident, even with the greatest care in manufacture and use, so long must the recurrence of disasters be expected. I will not dwell upon this subject, but wish to point out that the mining authority of the Province has taken every step possible to minimise these dangers by its examinations of men and officials.

The thanks of the Institute were presented to the PRESIDENT for his interesting address.

The report of the TREASURER was read and approved. The accounts had been audited by Messrs. Morton and O'Hearn and found correct.

The Report of the LIBRARIAN was presented by PROF. J. G. MACGREGOR. During the past year copies of the Transactions had been sent for the first time to 6 institutions in the United States, 3 in Canada, 2 in Germany, and 1 in England, and exchanges had been received for the first time from the following :—

Swedish Society for Anthropology and Geography, Stockholm.
Central Observatory, Xalapa, Mexico.
Natural Science Society, Carlsruhe.
Natural Science Society, Elberfeld.
Geographical Union of the North of France, Douai.
University of Vermont, Burlington, Vt.
Museum and Library of Filopenas, Filopenas.
Literary and Philosophical Society, Liverpool, G. B.
Royal Society of the Natural Sciences, Buda-Pest.

But few books had been bound owing to a lack of funds, consequent upon our having published in one year two annual Parts of the Transactions. Owing to lack of accommodation at the Post Office building it had been found necessary to remove the Canadian and Australian publications to the room courteously furnished at Dalhousie College by the Board of Governors. The only sections of the Library now at the Post Office building are the British and United States publications. The members had not made so much use of the Library as in other recent years, doubtless because of the increasing difficulty in gaining access to the books.

A vote of thanks was presented to MR. BOWMAN and PROF. MACGREGOR for their work in connection with the Library.

The following officers were elected for the ensuing year (1896-7) :—

President—E. GILPIN, JR., ESQ., LL.D., F.R.S.C.
Vice-Presidents—ALEXANDER MCKAY, ESQ., and A. H. MACKAY ESQ., LL.D., F.R.S.C.
Treasurer—W. C. SILVER, ESQ.
Corresponding Secretary—PROF. J. G. MACGREGOR.
Recording Secretary—HARRY PIERS, ESQ.
Librarian—MAYNARD BOWMAN, ESQ., B.A.
Councillors without office—MARTIN MURPHY, ESQ., D. SC. ; F., W. W. DOANE, ESQ., C.E. ; WILLIAM MCKERRON, ESQ. ; WATSON L. BISHOP, ESQ. ; S. A. MORTON, ESQ., M.A. ; P. O'HEARN, ESQ. ; RODERICK MCCOLL, ESQ., C.E.

It was resolved that the thanks of the Institute be conveyed to the HON. R. BOAK for his courtesy in permitting the use of the Legislative Council Chamber for the meetings of the Society. Also resolved that the thanks of the Institute be presented to the Secretary of the Smithsonian Institution, Washington, for his courtesy in granting the Institute the privileges of the Department of International Exchanges of the Institution.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th November, 1896.

The PRESIDENT in the chair.

PROFESSOR J. G. MACGREGOR, D. SC., read a paper "On the Relation of the Physical Properties of Aqueous Solutions to their State of Ionization." (See Transactions, p. 219).

The paper was discussed by MR. A. MCKAY, DR. A. H. MACKAY, and others.

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 14th December, 1896.

The PRESIDENT in the chair.

It was announced that the following gentlemen had been elected members of the Society :—LEE RUSSELL, ESQ., B. SC., Normal School, Truro ; T. C. MCKAY, ESQ., B. A., Dartmouth ; REV. BROTHER PETER, La Salle Academy, Halifax ; CHARLES TWINING, ESQ., Halifax ; and C. C. JAMES, ESQ., Deputy Minister of Agriculture, Toronto.

PROFESSOR E. E. PRINCE, Commissioner and General Inspector of Fisheries for Canada, delivered a lecture on "Recent Discoveries regarding the Eggs and Young of Fishes." The lecture was illustrated by a number of lantern views.

Remarks upon the subject were made by DRS. REID, MACKAY, SOMERS, and MURPHY, and also by the Chief Game Commissioner, C. S. HARRINGTON, ESQ., Q. C.

THIRD ORDINARY MEETING.

Legislative Council Chamber, Halifax, 11th January, 1897.

The First Vice-President, MR. MCKAY, in the chair.

The Secretary announced that PROFESSOR E. E. PRINCE, Commissioner and General Inspector of Fisheries for Canada, Ottawa, had been elected a Corresponding Member.

PROFESSOR J. G. MACGREGOR, D. SC., presented a paper "On the Relations of the Physical Properties of Solutions to their State of Ionization," second part. (See Transactions, p. 219).

The subject was discussed by PROFESSOR E. MACKAY and MR. J. FORBES.

FOURTH ORDINARY MEETING.

Provincial Museum, Halifax, 8th February, 1897.

The Second Vice-President, DR. MACKAY, in the chair.

REV. BROTHER PETER, of La Salle Academy, exhibited a number of Dried Plants, which he had collected in the vicinity of Halifax, and made remarks thereon.

In the absence of the author, a paper entitled, "Measurements of two Beothuk Skulls," by W. H. PREST, ESQ., was read by the Secretary :—

"Having been asked to give the measurements of two Beothuk skulls taken while at the Museum at St. John's, Newfoundland, I submit the following :

In order to more fully explain these measurements. I may say that the term brachy-cephalic, or round-headed, is used to denote skull forms where the proportion of the breadth to the length is as 80 and upwards to 100. The term dolicho-cephalic, or long-headed, denotes proportions of from 75 and downward to 100. All intermediate proportions are termed meso-cephalic.

No. 1. Adult skull marked No. 6 in the St. John's Museum Collection:

	INCHES.
Glabella to occipital point	7.425
Greatest width of skull	5.825
Bregma to occipital condyle	6.075
Resulting index, meso-cephalic	78.45

No. 2. Adult Female (?) *:*

	INCHES.
Glabella to occipital point	6.825
Greatest width of skull	5.600
Bregma to occipital condyle	5.700
Resulting index, brachy-cephalic verging on meso-cephalic	80.20

The measurements in the above instances, although taken without any very elaborate instruments, can not be in error more than $\frac{1}{80}$ of an inch. Another skull and skeleton, almost perfect, want of time prevented me from measuring. It, however, showed features of a decidedly lower type than the others, particularly in the enormous supercilliary ridges and narrow retreating forehead. The nose was extremely aquiline, as were those of the other skulls. It appears to approach the long-headed type more nearly than the others, but measurements of such a limited number of skulls cannot be considered as settling or even approximating the question of tribal index. Our chief hope, therefore, lies in the expectation of future explorations of Beothuk burying grounds. That the above skulls are genuine Beothuk remains, I give as authority Mr. Howley, Director of the Geological Survey of Newfoundland, through whose care all the relics of this interesting race are preserved. For further evidence as to their authenticity, I would give the name of Rev. M. Harvey, who discovered skull No. 1 at Pilley's Island, Notre Dame Bay, Newfoundland, under circumstances which leave no doubt that it was Beothuk.

Another Beothuk skull, which I do not think has been measured, is to be seen at McGill University, Montreal. It was found in 1847 by Rev. Mr. Blackmore, Rural Dean of Conception Bay, on a small island called Rencontre, one of the Lower Burgeo group, on the southern coast of Newfoundland.

In order to show more fully the position the Beothuks occupied in North America, I may say that the Indians are brachy-cephalic while the Esquimaux are dolicho-cephalic. These are the nearest races the boundaries between which lie in the neighbourhood of that part of Labrador nearest Newfoundland. The long-headed races seem to have belonged to an ancient type inferior as a rule to their round-headed brethren. And since paleolithic times they have been gradually pushed to the outlying parts of the earth. Therefore, the occurrence of an apparently intermediate form in Newfoundland is what we might expect from its position near the junction of two such different types."

The preceding notes are given in the hope that they may lead to systematic investigation of this now extinct race by some one more competent than myself. I am more desirous of this, as I have made a mistake in taking measurements for the vertical index from the bregma to the occipital condyle instead of to the basion. Scarcely within modern times has it been that a tribe has been so completely annihilated that even of its language hardly a remnant remains. The story of the persecution and slaughter of the Beothuks by the white man is a sad one. The history of Newfoundland contains a page—marked with blood and darkened with disgrace—a page that tells of inhuman slaughter and cruelty that makes the blood of every true man boil—the ruthless extermination of a harmless and despairing race."

A number of interesting remarks upon the subject were made by REV. DR. PATTERSON, of New Glasgow.

CHARLES TWINING, ESQ., then gave an account of some "New Arrangements in Sailing Gear." The subject was discussed by a number of those present.

FIFTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 8th March, 1897.

The Second Vice-President, DR. MACKAY, in the chair.

It was announced that JAMES FLETCHER, ESQ., LL.D., F. R. S. C.' F. L. S., Entomologist and Botanist, Central Experimental Farm, Ottawa, had been elected a Corresponding Member.

MR. PIERS was appointed delegate to represent the Institute at the June meeting of the Royal Society of Canada.

A paper by DR. GILPIN, on "Some Analyses of Nova Scotia Coals and other Minerals," was read by DR. MACKAY in the absence of the author. (See Transactions, p. 246).

Sixth Ordinary Meeting.

Legislative Council Chamber, Halifax, 12th April, 1897.

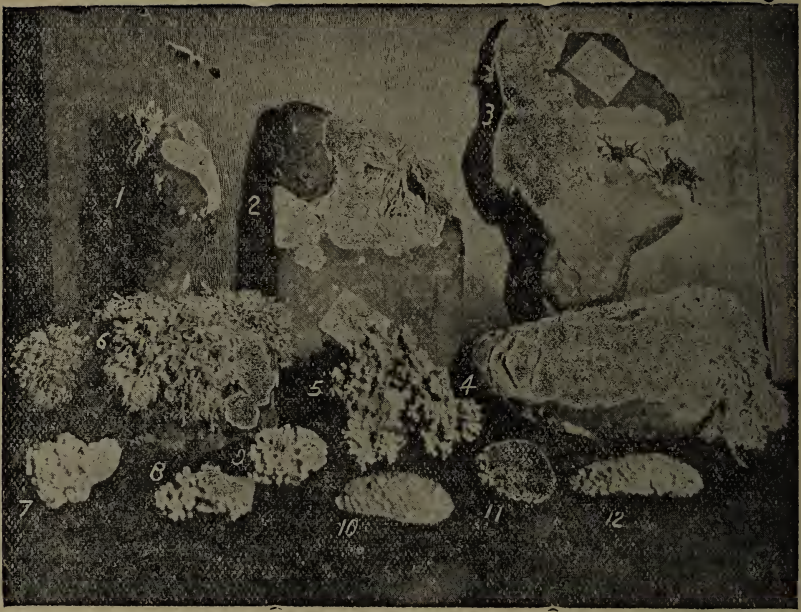
The President in the chair.

A communication was read from the Royal Society of London announcing that at a recent meeting of that body it had been unanimously resolved that a fund, to be called the Victoria Research Fund, be established, to be administered by representatives of the various scientific societies, for the encouragement of research in all branches of science. The Society wished to know if the scheme met with the approval of the Institute.

Resolved, That this Institute, having heard the communication of the 22nd February, addressed to its President by the President of the Royal Society of London, in reference to the proposal to establish a Research Fund in commemoratian of the present sixtieth year of the reign of Her Gracious Majesty the Queen, express its cordial approval of the proposal.

Resolved, *further*, That while the Institute is of opinion that no large contribution to the proposed fund can be expected from the Province of Nova Scotia, whose men of science are few, and whose industries have not yet reached the stage in which the advantages of scientific research become manifest, the Institute will be glad to co-operate with other scientific societies in Canada in bringing the claims of the proposed fund to the notice both of their members and of other citizens who may be expected to become contributors.

CALCAREOUS ALGÆ.



(Reduced to nearly one-fifth of actual diameter).

DR. A. H. MACKAY presented specimens of calcareous algæ for general examination, such as the incrustations shown on the stones at 1, 2, 3, 4, and 6 (above), which came from low water at Cranberry Head, near Yarmouth. Tufts of *Corallina officinalis*, L. were growing conspicuously from some parts of these ; 5, 7, 8, 9 and 11 were more or less tuberculose or branching incrustations of *Lithothamnion* on stones as a base, while 10 and 12 were incrusting mussel shells. His discussion of the group was preliminary to further work, and the exhibition of the specimens was to enlist the fellowship of additional collectors of these species. The *Corallineæ*, or calcareous algæ, which he was showing, came principally from Point Pleasant, within and opposite the mouth of Halifax harbor, although he had specimens all the way from Brier Island to Cape Breton. The *Corallineæ* belonged to the *Florideæ*, or red sea-weeds.

The genus *Corallina* grows in feather-like tufts composed of short articulations when examined closely. When growing, these fronds are of a darkish or light red color like that of the *dulse* and other red algæ.

They are soon bleached white by exposure to light, and after being dried become very brittle, the articulations falling apart. In addition to the red coloring matter there is a large amount of lime laid up with the tissue of each articulation, so that we have here plants which secrete lime from the sea water as the coral does among animals. Dilute hydrochloric acid applied to a portion of one of these fronds well covered with glass to protect the microscope, will show under a low power a rapid evolution of carbonic acid gas until the articulations of the frond become translucent, when all the lime is dissolved out of the vegetable tissue.

The genus *Melobesia* appears as small, thin, more or less circular incrustations of lime filled tissue on other algæ, generally. Thin incrustations on stones taken for *Melobesia Lenormandii* of Farlow are, probably, forms of *Lithothamnion compactum.*

The genus *Lithothamnion* forms larger incrustations, of a red or purple color before they are bleached, some of the species rising into minute nodules or tubercles, and others rising even into rudely branching coral-like masses. The name, from *lithos* a stone and *thamnion* a little bush, was suggested by the latter habit. The reproductive organs of all these are in conceptacles, small spherical cavities, either immersed in the general frond or rising out of it. They are difficult to section for microscopic examination, for if the calcium carbonate is dissolved out of the tissue by, say, dilute hydrochloric acid, no matter how gently it is done, the tissue is more or less disorganized so as not to show the minute parts distinctly. And the sectioning of the undecalcified plants is very severe on the razor or other cutting apparatus.

The two species of Farlow's Marine Algæ of New England, *L. polymorphum* and *L. fasiculatum*, the tubercular or lobular, and the branching species respectively, 5 above being the most distinctive of the latter, are found all along the coast. But from the studies of M. Foslie, of Trondhjem, Norway, these two general forms may be found to cover several distinct species. Probably the following more exact species are represented under these forms :—

Lithothamnion fruticulosum, (Kutz.) Foslie, f. *typica*, Foslie, the most conspicuous branching form. Next to it comes
L. colliculosum, Foslie. Then comes
L. glaciale, Kellm.
L. compactum, Kellm. And possibly,
L. conscriptum.

As these algæ have been very little studied hitherto, he hoped those having an opportunity to collect specimens, or who could get specimens which might be brought up in fishermen's nets, would bring them to the Museum of the Institute.

Dr. Somers made some remarks on the subject.

Harry Piers, Esq., then read a paper entitled, "Notes on Nova Scotian Zoology: No. 4." (See Transactions, p. 255).

The paper was discussed by Dr. Somers, Mr. Bishop, and Dr. Reid.

Seventh Ordinary Meeting.

Legislative Council Chamber, Halifax, 10th May, 1897.

The First Vice-President, Mr. McKay, in the chair.

A paper entitled, "A Supplementary Note on Venus," by Principal Cameron, of Yarmouth Academy, was read by Dr. MacKay. (See Transactions, p. 275).

The paper was discussed by Dr. Reid and the Chairman.

A. H. MacKay, Esq., Ll. D., F. R S. C, read a paper entitled, "Phenological Observations for 1896." (See Transactions, p. 268).

The subject was discussed by Professor MacGregor and the Chairman.

A paper on the "Rainfall of 1896," was then read by Mr. Doane. (See Transactions, p. 279).

Dr. Murphy, Dr. MacKay, and others, took part in the discussion which followed.

The following papers were then read by title:—

"On the Tides of the Bay of Fundy" (second paper). By Martin Murphy, Esq., D. Sc., Provincial Engineer.

"On the Water Supply of the Towns of Nova Scotia." By Proeessor W. R. Butler, M. E., King's College, Windsor.

HARRY PIERS,
Recording Secretary.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1896-97.

I.—On the Relation of the Physical Properties of Aqueous Solutions to their State of Ionization.—By Professor J. G. MacGregor, *Dalhousie College, Halifax, N. S.*

(Communicated 14th December, 1896.)

It has often been pointed out that, according to the dissociation or ionization conception of the constitution of a solution of an electrolyte, the difference between the physical properties of one in which ionization is complete and those of the solvent must be compounded additively of the differences produced by the two ions. It would seem to be equally obvious that, in the case of solutions in which the ionization is not complete, the differences referred to must be similarly compounded of those produced by the undissociated molecules and by the free ions; and if so, it should be possible to express the numerical values of the various properties in terms of the state of ionization. Such an expression would take its simplest form in the case of solutions so dilute that the molecules, dissociated or undissociated, might be regarded as sufficiently far apart to render mutual action between them impossible, and in these circumstances the change produced in the properties of the solvent by the undissociated and the dissociated molecules respectively might be expected to be simply proportional to their respective numbers per unit of volume. It is the object of this paper to test the applicability to sufficiently dilute solutions, of such an expression, viz.,

$$P = P_w + k(1 - a)n + lan, \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where P is the numerical value of any property (density, &c.), P_w that of the same property of water under the same physical conditions, n the molecular concentration of the solution, *i. e.*, the number of gramme-equivalents of the dissolved substance per unit volume of the solution, α the ionization-coefficient αn and $(1-\alpha)n$ consequently the numbers of dissociated and undissociated gramme-equivalents per unit of volume respectively, and k and l constants, which may be spoken of as ionization-constants, which will vary with the solvent, the substance dissolved, the property to which they apply, the temperature, and the pressure, but not with the concentration of the solution.

The formula can obviously apply only to properties for which P_w has a finite value. Thus it is inapplicable to electrical resistance, for which P_w would have a practically infinite value.

SIMPLE SOLUTIONS.

In order to test the applicability of the above expression I have determined the ionization-constants for the density, thermal expansion, viscosity, surface-tension, and refractive index of solutions of Sodium and Potassium Chlorides, by the aid of observations made by Bender *, Brückner †, and Rother ‡. I selected these observations as a first instalment, not because of their precision (for in one or two cases more exact observations are available), but because these observers, in all cases but one, determined the values of the above properties for mixtures of solutions as well as for simple solutions. I selected the above chlorides partly because I thought it well to begin with salts of simple molecular structure, but largely also because, for the purpose of calculating the conductivity of mixtures of them (as described in my paper on this subject §), I had already obtained interpolation formulæ and curves which, judged by the results of that paper, gave with considerable accuracy the ionization-coefficients of the simple solutions of these salts in terms of their molecular concentration. To save space I may tabulate here the values of the ionization-coefficients used in the calculations for simple solutions. They are as follows :—

---

* Wied. *Ann.* vol. xxii. (1884) p, 184, and vol. xxxix. (1890) p. 89.

† *Ibid.* vol. xlii. (1891) p. 293.

‡ *Ibid.* vol. xxi. (1884) p. 576.

§ Trans. N. S. Inst. Sci. ix. (1896) p. 101; and Phil. Mag. [5] xli. (1896) p. 276.

SODIUM CHLORIDE.		POTASSIUM CHLORIDE.	
Grm.-mols. per litre.	Ionization-coefficient at 18° C.	Grm.mols. per litre.	Ionization-coefficient at 18° C.
·25	·792	·1875	·8267
·5	·736	·3402	·811
·8928	·6866	·375	·796
1·0	·676	·5	·788
1·5	·633	·6856	·769
1·8353	·601	·75	·768
2·0	·5866	1·0	·756
2·5	·5504	1·0467	·755
2·8373	·5255	1·4292	·731
3·0	·514	1·5	·731
3·9375	·4516	2·0	·712
		2·185	·7048
		2·5	·695
		2·986	·681
		3·0	·680

These coefficients were obtained from Kohlrausch and Grotrian's and Kohlrausch's observations of conductivity at 18° C.* In obtaining them I took the specific molecular conductivity (referred to mercury) at infinite dilution to be 1216×10^{-8} for KCl, and 1028×10^{-8} for NaCl, not being aware at the time that Kohlrausch had given 1220 and 1030 respectively as more exact values. Nevertheless, to save labor, I have used the above values of α in the calculations of this paper, having satisfied myself by a re-calculation in one case that no appreciable difference in the results would be produced by the employment of more exact values. It will be noticed that in one or two cases the above values of α are obviously a little out; but they would seem to be sufficiently accurate for my purpose. I did not foresee the extent of the calculations, or I should have determined all the values of α required at the outset, and checked them by comparison with one another.

---

* Wied. *Ann.* vi. (1879) p. 37, and xxvi. (1885) p. 195.

I have determined the ionization-constants (k and l) in all cases in which more than two observations of a property on solutions of sufficient dilution were available, by the method of least squares. The constants thus determined and used in the calculations are tabulated below. In all cases the available observations had been made on solutions of such great concentration that the values of the constants obtained cannot be regarded as exact; but the calculations may serve as a test of the general applicability of the expression referred to above. The only available observations, as far as I know, on solutions of sufficient dilution for the determination of the ionization-constants and the limits of concentration within which the above expression is applicable, are those by Kohlrausch and Hallwachs * on the specific gravity of dilute solutions, from which two of my students have undertaken to determine the density-constants for the salts and acids examined.

With regard to the observations which I used in determining the various ionization-constants, the following statements should be made :—

Bender's determinations of density (*i. e.* specific gravity referred to water at 4° C.) were made at 15° C., but were readily reduced to 18° by the aid of his observations on the thermal expansion between 15° and 20° of the same solutions. According to his statement, the fourth place of decimals in his values may be in error by ±2 or ±3. The density of water was taken to be 0·99863.

Bender's determinations of thermal expansion are for the interval between 15° and 20° C., and will therefore be sufficiently nearly proportional to the coefficients of expansion at 18° for my purpose. He considers that they may be in error by ±2 in the sixth place of decimals. On plotting his observations, however, it becomes obvious that they do not all attain this degree of accuracy. The expansion of water was taken, according to his observations, to be $0{\cdot}0_3878$ for the same interval.

---

* Wied. *Ann.* liii. (1894) p. 14.

Brückner's observations of viscosity were made at 15° C.; but he gives an interpolation formula, applicable between 15° and 20°, by means of which at least approximate values for 18° were obtained. His values for water at 15° and 20° do not agree well with those given by Landolt and Börnstein. I have therefore taken 0·010613 as the viscosity at 18° of the water used by him, a value which has to his value at 15° the same ratio as Landolt and Börnstein's for the same temperatures. The actual concentrations of Brückner's solutions differed from those given in the tables below by about 0·1 per cent.; but so small a difference could produce no appreciable error in the result. He gives as his "mean probable error of observation," ±2·4 in the fifth place of decimals for sodium-chloride solutions, and ±1·8 for those of potassium chloride.

Rother's observations of surface-tension were made at 15° and are therefore not precisely comparable with calculated values based on the values of ionization-coefficients for 18°. From Kohlrausch's data,* however, it would appear that between 15° and 18° in the case of potassium-chloride solutions containing 0·5 and 3 gramme-molecules per litre, the ionization-coefficient changes only by about 0·13 and 1·3 per cent. respectively; and in the case of sodium-chloride solutions of the same concentrations only by about 0·4 and 0·6 per cent. respectively. For the more dilute solutions, therefore, my calculations will be practically comparable with Rother's observations. He seems to regard his determinations as possibly in error by ±5 to 8 in the the third place of decimals. The surface-tension of the water he used he found to be 7·357.

Bender's observations of refractive index were made at 15° C., but were reduced to 18° by means of data provided in his paper, based on observations made by Fouqué†. The refractive index of the water he used he found to be 1·33310

---

* Wied. *Ann.* xxvi. (1885) p. 223.

† *Compt. Rend.* lxiv. (1867) p. 121.

SODIUM CHLORIDE SOLUTIONS.				POTASSIUM CHLORIDE SOLUTIONS.			
Grm.-mols. per litre.	Observed Value.	Calc. Value.	Difference.	Grm.-mols. per litre.	Observed Value.	Calc. Value.	Difference.
DENSITY (BENDER'S OBSERVATIONS).							
0.25	1.00898	1.00916	$+0.0_{3}18$	0.1875	1.00752	1.00731	$-0.0_{3}21$
0.5	1.01930	1.01929	− 01	0.375	1.01567	1.01586	+ 19
1.0	1.03925	1.03910	− 15	0.75	1.03317	1.03278	− 39
1.5	1.05834	1.05842	+ 08	1.0	1.04362	1.04401	+ 39
2.0	1.07772	1.07701	− 71	1.5	1.06630	1.06621	− 09
2.5	1.09633	1.09532	$-0.0_{2}101$	2.0	1.08767	1.08823	+ 56
				2.5	1.10755	1.11008	$+0.0_{2}253$
				3.0	1.13057	1.13177	+ 120
THERMAL EXPANSION (BENDER'S OBSERVATIONS).							
0.25	.001013	.001022	$+0.0_{5}9$	0.1875	.000963	000966	$+0.0_{4}03$
0.5	.001141	.001141	± 0	0.375	.001037	.001040	+ 03
1.0	.001357	.001349	− 8	0.75	.001183	.001173	− 10
1.5	.001522	.001526	+ 4	1.0	.001249	.001255	+ 06
2.0	.001663	.001657	− 6	1.5	.001395	.001395	± 00
2.5	.001776	.001769	− 7	2.0	.001500	.001517	+ 17
3	.001876	.001848	$-0.0_{4}28$	2.5	.001580	.001621	+ 41
VISCOSITY (BRÜCKNER'S OBSERVATIONS).							
0.5	.010988	.010978	$-0.0_{4}10$	0.5	.010457	.010451	$-0.0_{4}06$
1.0	.011480	.011475	− 05	1.0	.010395	.010379	− 16
1.5	.012048	.012047	− 01	1.5	.010351	.010366	+ 15
2.0	.012707	.012730	+ 23	2.0	.010394	.010393	− 01
2.5	.013472	.013458	− 14	2.5	.010444	.010457	+ 13
3.0	.014373	.014267	$-0.0_{3}106$	3.0	.010566	.010555	− 11
SURFACE-TENSION (ROTHER'S OBSERVATIONS).							
0.8928	7.482	7.482	±0.000	0.3402	7.411	7.408	−0.003
1.8353	7.629	7.629	± 0	0.6856	7.460	7.462	+ 2
2.8373	7.780	7.798	+ 18	1.0467	7.518	7.519	+ 1
3.9375	7.954	7.997	+ 43	1.4292	7.584	7.583	− 1
				2.1851	7.705	7.709	+ 4
				2.9859	7 844	7.846	+ 2
REFRACTIVE INDEX, D LINE (BENDER'S OBSERVATIONS).							
0.5	1.33824	1.33824	$\pm 0.0_{3}00$	0.5	1.33803	1.33806	$+0.0_{3}03$
1.0	1 34307	1.34306	− 01	1.0	1.34278	1.34274	− 04
1.5	1 34770	1.34770	± 00	1.5	1.34721	1.34722	+ 01
2.0	1.35213	1.35206	− 07	2.0	1.35179	1.35158	− 21
2.5	1.35673	1.35632	− 41	2.5	1.35623	1.35582	− 41

at 18° for the D line. He seems to regard his observations as possibly in error by ±1 in the fourth decimal place.

The tables on page 224 contain the results of the calculations of the values of the physical properties mentioned, with both the observed values on which the determination of the constants was based, and a few additional observed values for stronger solutions.

The following comments may be made on these tables:

Density.—NaCl. The first four observations were used in determining the constants; and up to a concentration of 1·5 the differences are within the limits of experimental error, and show a satisfactory alternation of sign.—KCl. The first five observations were used. The differences are large, but the alternation of sign shows that the expression is applicable. On plotting Bender's values they are readily seen not to lie on a smooth curve.

Thermal Expansion.—NaCl. The first four observations were used. The differences up to a concentration of 2·5 are probably within the limits of experimental error, and their alternation of sign is satisfactory.—KCl. The first five observations were used. The differences are not so satisfactory as in the case of the sodium salt either as to magnitude or sign; but on plotting the observations the third is seen to be somewhat out; and it is obviously to this observation that the defective agreement is due.

Viscosity.—NaCl. The first five observations were used. The differences are within the limits of error, but the signs are not satisfactory. The fourth observation, however, appears to be defective. Mützel*, in applying a formula for viscosity in terms of density and concentration to these observations, found also that this observation was out. It is worth noting, also, that Mützel found his formula, which expressed the increase of viscosity due to the salt in solution on the assumption that the only action occurring was between salt and water, was applicable to only the first five of the above observations. To represent the viscosity of stronger solutions he had to introduce a term expressing the effect due to the mutual action of the molecules of salt.—KCl. All six observations were used. The agreement in this case is quite satisfactory.

---

* Wied. *Ann.* xliii. (1891) p. 35.

Surface-Tension.— NaCl. Only two observations on sufficiently dilute solutions were available, and the applicability of the formula cannot therefore be tested. The constants were found, for use in the calculation of the surface-tension of mixtures.—KCl. The first four observations were used, and the agreement is quite satisfactory up to a concentration of 3 grm.-mols. per litre.

Refractive Index.—In the case of both salts the first three observations were used, and in both the agreement is quite satisfactory up to a concentration of about 2 grm.-mols. per litre.

The above tables seem to be at any rate quite consistent with the possibility of expressing the values of at least five of the physical properties of moderately dilute solutions in terms of their state of ionization. I hope to find leisure at an early date to extend the investigation to solutions of salts and acids of a more complex character and to other properties.

The following are the ionization-constants used in the above calculations:—

	SODIUM CHLORIDE.		POTASSIUM CHLORIDE.	
	k.	*l.*	*k.*	*l.*
Density	+ ·030841	+ ·045079	+ ·03543	+ ·048591
Thermal Expansion.	− ·0001445	+ ·0007658	− ·000614	+ ·00069685
Viscosity	+ ·002347	+ ·0001504	+ ·001904	− ·0009247
Surface-Tension	+ ·20574	+ ·11001	+ ·24249	+ ·126806
Refractive Index...	+ ·006318	+ ·011713	+ ·0027853	+ ·011853

These constants are obtained from solutions of too great concentration to be regarded as exact values. Nevertheless it may be admissible, tentatively, at least, and so far as these two salts are concerned, to draw the following conclusions:—Undissociated and dissociated molecules are nearly equally effective in increasing the density,—those dissociated, however, being somewhat the more effective of the two. (2) Undissociated molecules diminish the thermal expansion, those dissociated increasing it to a greater extent. (3) In the case of viscosity it is the undissociated molecules which have the preponderating influence, those dissociated having but a slight effect, which may be an increasing or a diminishing effect. Thus Arrhenius's expectation that all dissociated ions would be found to diminish viscosity seems to be only partially realized, though possibly from observations on more dilute solutions, both l's might be found to be negative. (4) In the increase of surface-tension the undissociated molecules have about twice as great an influence as the dissociated. (5) In increasing the refractive index it is the dissociated molecules which have the preponderating influence; and their superiority is greater in increasing the refractive power than increasing the density.

MIXTURES OF SOLUTIONS.

For a solution containing several salts, 1, 2, etc., the value of a property, according to the conception under consideration, will be:—

$$P=P_w+k_1(1-a_1)n_1+l_1a_1n_1+k_2(1-a_2)n_2+l_2a_2n_2+\&c., \quad . \ (2)$$

the n's being numbers of gramme-equivalents per unit volume o the solution. If the solution have been formed by the mixture of the volumes v_1 and v_2 of two simple solutions of salts, having one ion in common, for which, before the mixing, the property had the values:—

$$\left.\begin{aligned}P_1&=P_w+k_1(1-a_1)n_1+l_1a_1n_1,\\P_2&=P_w+k_2(1-a_2)n_2+l_2a_2n_2,\end{aligned}\right\} \quad . \quad . \quad (3)$$

then, since on mixing, the state of ionization will, in general, change, we shall have as the value of the property for the mixture, assuming no change of volume on mixing,

$$P = P_w + (k_1(1 - a_1')n_1 + l_1 a_1' n_1)\frac{v_1}{v_1 + v_2} + (k_2(1 - a_2')n_2 + l_2 a_2' n_2)\frac{v_2}{v_1 + v_2}, \quad (4)$$

the n's being numbers of gramme-equivalents per unit volume of the original simple solutions, and α_1' and α_2' being the ionization-coefficients in the mixture. As the values of the k's and l's have been determined above for sodium and potassium chloride for a number of properties, and, as I have shown in my paper on the "Conductivity of Mixtures," cited above, how the ionization-coefficients after mixing may be determined, it should be possible to predict the values of these properties for mixtures of solutions of these salts.

The following tables show that this can be done. The ionization-coefficients were determined in the way described in the paper referred to. The constants k and l employed in the calculations were those determined above. The observations were made by the authors whose determinations for simple solutions were used above; in fact in most cases it was the solutions of the tables given above which were mixed. The limits of experimental error are thus of about the magnitudes mentioned above in each case. All remarks made above with regard to the reduction of observations to 18° C., the values of the property for water, etc., apply also to the mixtures. In all cases, except that of surface-tension, the solutions mixed were mixed in equal volumes. Unfortunately, Bender made no observations on the refracting power of mixtures.

Constituent Solutions (grm.-mols. per litre.)		Ionization Coefficients in Mixture.		Observed Value.	Calculated Value.	Difference.
NaCl.	KCl.	NaCl.	KCl.			
DENSITY (BENDER'S OBSERVATIONS).						
1·0	0.1875	.7268	.7720	1.02358	1.02350	$-0.0_3 08$
"	0.375	.714	.7625	1.02785	1.02766	− 19
"	0.75	.688	.7629	1.03641	1.03600	− 41
"	1.0	.6728	.7632	1.04139	1.04158	+ 19
"	1.5	.6494	.7478	1.05293	1.05263	$-0.0_3 30$
"	3.0	.6143	.7283	1.08580	1.08595	+ 15
THERMAL EXPANSION (BENDER'S OBSERVATIONS).						
1.0	0.1875	.7268	.7720	.001174	.001174	$\pm 0.0_4 00$
"	0.375	.714	.7625	.001208	.001203	− 05
"	0.75	.688	.7629	.001275	.001264	− 11
"	1.0	.6728	.7632	.001297	.001305	+ 08
"	1.5	.6494	.7478	.001376	.001376	± 00
"	3	.6143	.7283	.001543	.001596	+ 53
VISCOSITY (BRÜCKNER'S OBSERVATIONS).						
1.0	0.5	.7059	.7635	.010940	.010947	$+0.0_4 07$
"	1.0	.6728	.7632	.010918	.010920	+ 02
"	1.5	.6494	.7478	.010876	.010915	+ 39
"	2.0	.6143	.7283	.010890	.010956	+ 66

SURFACE TENSION (ROTHER'S OBSERVATIONS).

CONSTITUENT SOLUTIONS.				Ionization Coefficients in Mixture.		Observed Value.	Calculated Value.	Difference.
Concentration (grm.-mols. per litre).		Volume (litres.)						
NaCl.	KCl.	NaCl.	KCl.	NaCl.	KCl.			
0.8862	0.6836	0.14487	0.14545	0.6906	0.7632	7.477	7.472	− 0.005
1.8109	1.411	0.13993	0.14096	0.6087	0 7279	7.607	7.602	− 5
0.8824	2.1822	0.14489	0.13659	0.6123	0.7311	7.600	7.591	− 9
2.8406	0.6862	0 13511	0.14544	0.6027	0.7298	7.622	7.616	− 6
1.8155	2.9887	0.13996	0.13241	0.5185	0.7125	7.734	7.810	+ 76

It will be noticed that in the case of the third mixture of the density and thermal expansion series (the same mixture) the differences are comparatively large; but it is obvious from the data of the fourth column in these series that the ionization-coefficients have not been accurately determined for mixtures of about the concentration of the one referred to. With these exceptions the agreement between observed and calculated values is satisfactory, the differences being either well within, or at worst on, the limit of observational error, up to mean concentrations of about 1.5. The determination of the ionization-coefficients was especially difficult in the case of the surface-tension observations, because Rother mixed equal weights of his simple solutions, not equal volumes. Nevertheless, in all except the strongest of these mixtures, the differences are probably not beyond the limits of experimental error. Obviously, alternation of sign is not to be expected in these calculations.

RELATIVE VALUES OF A PROPERTY FOR A MIXTURE AND FOR ITS CONSTITUENTS: "CORRESPONDING" SOLUTIONS.

As change of ionization in general occurs on mixing two solutions, it follows from (3) and (4) that the value of a property for a mixture of two solutions having one common ion will differ from the volume-mean, $(v_1 P_1 + v_2 P_2)/(v_1 + v_2)$, of its values for the constituents by the amount

$$(l_1 - k_1)\frac{n_1 v_1}{v_1 + v_2}(a_1' - a_1) + (l_2 - k_2)\frac{n_2 v_2}{v_1 + v_2}(a_2' - a_2) \quad \ldots\ldots\ldots \quad \ldots(5)$$

The name of "corresponding" solutions has been given to solutions for which this quantity vanishes. In general it will obviously have a value, though that value may be small.

In most cases this conclusion is borne out by experience. But Rother has concluded from his observations that, in the case of surface-tension, throughout a wide range of concentration, solutions of all concentrations are "corresponding." Were this the case it would throw serious doubt on the possibility of expressing surface-tension in terms of state of ionization. If, however, with the aid of the constants for surface-tension determined above, we compute, in the case of Sodium and Potassium Chlorides, the difference between the value for a mixture and the volume-mean of the values for its constituents, we find it to be beyond the limit of Rother's power of observation. Thus, in the case of his first mixture calculated above, the difference amounts to only 0.0_315. His conclusion should thus have been that the difference, if any, between the surface-tension of a mixture and the volume-mean of those of its constituents was within the limits of his experimental error. He might even have concluded, however, that there was probably such a difference in the case of Sodium and Potassium Chlorides; for in all the mixtures of solutions of these salts which he examined, the volume-mean of the values for the constituent solutions were found to be less than the values for the mixtures.

The above expression (5) will vanish if the constituents of the mixture are isohydric, *i. e.*, have states of ionization which do not change in the mixing; and it will vanish in that case, whatever the values of the other quantities involved in the expression may be. When the constituents are not isohydric the condition of its vanishing will be

$$\frac{n_1}{n_2}=\frac{(l_2-k_2)(a_2'-a_2)v_2}{(l_1-k_1)(a_1-a_1')v_1} \quad \text{........................(6)}$$

It is obviously improbable that in any case in which this condition may be fulfilled the numbers of gramme-equivalents per litre in the constituent solutions will have a simple relation, such as 1 : 2, 4 : 3, &c.

The conclusions drawn by Bender and Brückner from their observations on density, thermal expansion, electrical conductivity, and viscosity, viz., that there is such a simple relation in the case of all "corresponding" solutions, so far as the properties mentioned are concerned, is thus inconsistent with the possibility of expressing the values of these properties in terms of the state of ionization.

Both Bender[*] and Brückner[†] obtained their results from numerous series of observations, in each of which a solution of given concentration of one salt was mixed in succession, in equal volumes, with a number of solutions of different concentrations of a second salt having one ion in common with the first. The values of the property under consideration were determined both for the simple solutions and for the mixtures, and the arithmetic means of the values for the constituents of the several mixtures were found. Curves were then plotted with molecular concentrations of the simple solutions of the second salt as abscissæ, and the observed values for the mixtures and the arithmetic means of the values for the constituents, respectively, as ordinates. The "corresponding" solutions were indicated by the points of intersection or contact of these curves. In all cases the two curves for each series are found to run very close together, so close that it is impossible to determine exactly at what points they touch or cross; and when the observational errors admitted by the authors are taken into account, they must be considered to be within touching or crossing distance at considerable distances on each side of the points at which Bender and Brückner assumed them to be contact or to intersect. I have plotted a number of these curves so as to indicate accurately all significant figures, and have found, on taking possible errors of observation into account, that in no case can a more definite conclusion be drawn than that "corresponding" solutions have pretty nearly the simple relations as to concentration claimed by the authors. It is not necessary to enter into details; but I may, by way of illustration, give the following:—

---

[*] Wied. *Ann.* xxii. (1884) p. 184, and xxxix. (1890) p. 89.

[†] *Ibid.* xlii. (1891) p. 293.

Molecular Concentrations of Corresponding and Isohydric Solutions.

NaCl.	KCl.		
	Values between which curves may be in contact.	Value assigned by Observer.	Isohydric Solution.
CONDUCTIVITY (BENDER'S OBSERVATIONS).			
0.5	0—1.0	0.375	0.47
1	0—1.1	0.75	0.89
2	1.2—1.5	1.5	1.60
3	1.8—2.55	2.25	2.20
4	2.6—3.15	3.0	2.57
VISCOSITY (BRÜCKNER'S OBSERVATIONS).			
1	0.5 —1.9	1.0	1.2
2	1.25—2.5	2.0	2.6

The fourth column of the above table gives approximate values of the concentration of the solutions of KCl (obtained from Kohlrausch's data) which are isohydric with the solutions of NaCl in the first column; and it will be noticed that in most cases these values are within the limits within which Bender's and Brückner's curves must be regarded as being possibly in contact.

It would thus appear that both Bender and Brückner drew too definite conclusions from their observations, and that the observations themselves are not inconsistent with the applicability of expression (1) to the physical properties of solutions.

APPLICATIONS OF THE ASSUMED LAW OF IONIZATION-CONSTANTS.

RATIO AND DIFFERENCE OF THE VALUES OF A PROPERTY FOR SOLUTION AND SOLVENT.

If the expression under consideration is applicable to solutions of moderate dilution it should give by deduction the laws which have been found to hold for particular properties of such solutions, and might be expected to be of use in showing their relation to one another. I need not refer here to the more obvious of such deductions, as, for example, the properties of non-electrolytes, or of electrolytes at extreme dilution, but may restrict myself to cases in which both constants k and l play a part.

The ratio of P to P_w will be

$$\frac{P}{P_w}=1+\frac{k+(l-k)a}{P_w}n.$$

For dilute electrolytes throughout a certain range of concentration, and through a wider range in the case of non-electrolytes, α varies but slightly with n. Throughout such range the coefficient of n in the above expression will thus vary but slightly. Hence, n being small,

$$\frac{P}{P_w}=e^{\frac{k+(l-k)a}{P_w}n}=A^n,$$

approximately, where e is the base of Napier's logarithms and A a constant. Arrhenius,* Reyher† and Wagner‡ have found this result to hold in the case of the viscosity of both classes of solutions.

The difference between P and P_w will be

$$P-P_w=(k+(l-k)a)n.$$

and for the reason just given, will, throughout a certain range of low concentration, wider in the case of non-electrolytes than in that of electrolytes, be approximately proportional to n. This form of the expression obviously includes such laws as Raoult's for vapour tensions, and van 't Hoff's for the depression of the freezing point in non-electrolytes, as well as the approximate proportionality of the rotation of the plane of polarisation to concentration. It has recently been verified by Kohlrausch and Hallwachs's observations on density,§ they having found

---

[*] Ztschr. f. phys. Chemie, i, (1887) p. 285.

[†] Ibid. ii, (1888), p. 753.

[‡] Ibid. v, (1890), p. 31.

[§] Wied. *Ann.*, liii, (1894), p. 36.

that between concentrations of 0.005 and 1 gramme-equivalent per litre, $(P - P_w)/n$ varies in the case of certain salts and acids only by from 5 to 20 per cent, and in the case of sugar only by 1.5 per cent.

VARIATION OF TEMPERATURE AND OTHER COEFFICIENTS WITH CONCENTRATION.

The temperature-coefficient of any property of a solution of given concentration will be

$$\frac{1}{P}\frac{\delta P}{\delta t} = \frac{\frac{\delta P_w}{\delta t} + \frac{\delta k}{\delta t} n + \left(\frac{\delta l}{\delta t} - \frac{\delta k}{\delta t}\right) an + (l - k)\frac{\delta a}{\delta t} n}{P_w + kn + (l - k)an} \qquad \text{(7)}$$

The pressure-coefficient will have the same form, p being written for t. The concentration-coefficient will be

$$\frac{1}{P}\frac{\delta P}{\delta n} = \frac{k + (l - k)\left(a + \frac{\delta a}{\delta n} n\right)}{P_w + kn + (l - k)an} \qquad \text{(8)}$$

In the case of a solution of a given salt of given concentration, temperature, and pressure, α, n, and α's rates of change have definite values the same for all properties. For moderately dilute solutions, $\delta\alpha/\delta t$, $\delta\alpha/\delta p$*, and $\delta\alpha/\delta n$ are all small, and $\delta\alpha/\delta t$ and $\delta\alpha/\delta n$ at least have the same sign. Also the k's and l's for the different properties all depend upon the mutual action between molecules and solvent, and may thus be expected to have more or less closely related values. We may therefore expect not only that the coefficients of one kind for the various properties of solutions of a given salt will vary with concentration in a somewhat similar manner, but also that the variation with concentration of all the coefficients, but especially the temperature and pressure-coefficients, will exhibit a certain family likeness. It is obviously not to be expected that the variation will be exactly similar in any case.

This family likeness has been observed in the case of the temperature-coefficients for electrical conductivity and fluidity by Grotrian*, who found that, in general, with increasing concentration both of these temperature-coefficients undergo changes in the same sense. Grossmann† claimed to have proved these coefficients to be equal; but afterwards withdrew the claim as based on an error‡. Kohlrausch and Hallwachs also have noticed for very dilute solutions a close similarity between the curves representing the density and the conductivity respectively of the same salt as functions of the concentration.

---

* I have not seen Röntgen's paper, on which the statement that $\delta a/\delta p$ is small is based. The *Fortschritte der Physik* reports Tammann as quoting him to that effect.

The following tables show that this family likeness extends, to a greater or less extent, to all the coefficients for at any rate a considerable number of the properties of solutions. The tables include some of Grotrian's coefficients with others calculated from the observations of Kohlrausch, Bender, Brückner, Rother, Röntgen and Schneider§, Fink ||, and Timberg ¶. The coefficients are in almost all cases mean values, the ranges of temperature, &c., to which they apply, though the smallest for which data are available, being not in all cases the same. As I wish to show only a general similarity, it is not necessary to specify the ranges. The temperatures, &c., of the lower limits of the ranges are also not in general exactly the same. The data of the tables are thus not exactly comparable; but they are sufficiently so for my purpose. The heading *n* stands for gramme-equivalents per litre.

---

* Wied. *Ann.* viii. (1879) p. 552.

† *Ibid.* xviii. (1883) p. 119.

‡ See Kohlrausch, Wied. *Ann.* xxvi. (1885) p. 224.

§ Wied. *Ann.* xxix. (1886) p. 194.

|| *Ibid.* xxvi. (1885) p, 505.

¶ *Ibid.* xxx. (1887) p. 545.

SODIUM CHLORIDE SOLUTIONS.

Temperature Coefficients for						Pressure Coefficients for				Concentration Coefficients for							
Conductivity.		Fluidity.		Density.		Conductivity.		Density.		Conductivity.		Fluidity.		Density.		Surface Tension.	
n.	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.
.883	.0218	1.441	.0245	1.	$-.0_3271$	.170	$.0_4801$	.712	$.0_4429$	.5	1.67	.5	—.0895	.5	.0394	.895	.0209
1.828	.0215	2.694	.0243	1.5	$-.0_3304$	.882	$.0_4600$	1.496	$.0_4394$	1	0.639	1.5	—.1081	1.5	.0368	1.835	.0198
2.839	.0213	4.655	.0252	2.	$-.0_3333$	1.828	$.0_4491$	2 651	$.0_4352$	3	0.122	3.	—.1532	3	.0314	2.837	.0203
3.918	.0217			2.5	$-.0_3355$	2.806	$.0_4381$	3.941	$.0_4313$							3.937	.0243
5.078	.0228			3.	$-.0_3375$	3.835	$.0_4083$	5.420	$.0_4277$								
						5.059	$-.0_4110$										
						5.421	$-\ 0_4142$										

BARIUM CHLORIDE SOLUTIONS.

Temperature Coefficients for						Concentration Coeffts. for	
Conductivity.		Fluidity.		Density.		Conductivity.	
n.	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coefficient.
.501	.0215	.781	.0240	1.	$-.0_3258$	.5	1.629
1.051	.0207	1.704	.0226	1.5	$-.0_3290$	1.0	.610
1.652	.0201	2.945	.0222	2.	$-.0_3318$		
2.314	.0196			2.5	$-.0_3341$		
2.895	.0193			3.	$-.0_3361$		

CALCIUM CHLORIDE SOLUTIONS.

Temperature Coefficients for Surface Tension.	
n.	Coefficient.
About 6.4	$-.0_2134$
" 10	$-.0_2179$

A glance at these tables shows that if regard be had to sign, Grotrian's conclusion as to the temperature-coefficients for conductivity and fluidity applies to all the coefficients for all the properties tested. A given change in the concentration produces a change in the coefficients in the same sense. Too much importance, however, must not be attached to this; for it is obvious that if we should tabulate, say, the coefficients for conductivity, surface tension, viscosity (instead of fluidity) and specific volume (instead of density), it would be found that the changes produced in the first two are in the opposite sense to those produced in the last two. It is interesting, however, to note that the expectation suggested by the above formulæ is distinctly realized.

At very great dilution of electrolytes, the temperature-coefficient becomes, approximately,

$$\frac{1}{P}\frac{\delta P}{\delta t} = \left(\frac{\delta P_w}{\delta t} + n\frac{\delta l}{\delta t}\right) / (P_w+nl), \quad \ldots\ldots\ldots\ldots \quad (9)$$

the pressure-coefficient having the same form. The concentration-coefficient becomes

$$\frac{1}{P}\frac{\delta P}{\delta n} = l / P_w+nl) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots , \quad (10)$$

If we compare (9) and (10) with (7) and (8), it becomes obvious that the variation with concentration of the temperature and pressure coefficients will probably be more closely related at low than at high concentrations, but that the opposite will be true of the concentration coefficients. Accordingly, having plotted Grotian's coefficients and those of the above tables as functions of the concentration, I find that the temperature coefficient curves, for any one substance in solution, are in general more closely similar at low than at high concentrations; but that this is not the case for the concentration coefficient curves. In the case of the pressure coefficients the data are insufficient.

A corresponding similarity holds for the absorption spectra of solutions though it cannot be expressed in coefficients. In a former paper * I have shewn that for all solutions for which

---

* Trans. Roy. Soc. Can., ix (1891), sec. 3, p. 27.

data were available, the absorption spectra were similarly affected by elevation of temperature and increase of concentration.

THE OCCASIONAL CONSTANCY IN THE DIFFERENCE BETWEEN THE MOLECULAR VALUES OF PROPERTIES OF SOLUTIONS HAVING THE SAME MOLECULAR CONCENTRATION.

The difference between the values per gramme-equivalent of any property for two simple solutions, 1 and 2, of different electrolytes but of the same concentration, will be

$$(P_1-P_2)/n=k_1-k_2+(l_1-k_1)\,a_1-(l_2-k_2)\,a_2 \qquad (11)$$

Now α in all cases diminishes as n increases. Provided therefore, the values of the $(l-k)$'s have the same sign, and the rates of change of the α's with concentration are inversely proportional, or approximately so, to the $(l-k)$'s of their respective solutions, we shall have $(P_1-P_2)/n$ exactly or approximately constant. If we regard $(P_1-P_2)/n$ as approximately constant when its absolute value changes with n only to a small extent, then the more nearly the $(l-k$'s) and the α's are inversely proportional to one another the more nearly constant will $(P_1-P_2)/n$ be. If, however, we regard this quantity as constant when its values for different values of n differ from one another by only a small percentage, then the magnitude of the $(l-k)$'s becomes of importance, and we may have $(P_1-P_2)/n$ approximately constant, even though the $(l-k)$'s may be far from being inversely proportional to the α's.

In the case of certain solutions of moderate strength, this approximate constancy of $(P_1-P_2)/n$ has been observed by Valson and Bender* for the density and the refractive index, by Wagner † for viscosity constants, and by Jahn ‡ for the electro-magnetic rotation of the plane of polarization; and a very close approximation to constancy in the case of the specific gravities of very dilute solutions is clearly shewn in the results of Kohlrausch and Hallwachs's observations§.

---

* Wied. *Ann.*, xxxix, (1890), p. 89.

† Ztschr. f. phys. Chemie, v. (1890), p. 31.

‡ Wied. *Ann.*, xliii, (1891), p. 280.

So far as Sodium and Potassium Chlorides are concerned, Bender found that in respect to their density at 15° C.;

For n =	1·0	2·0	3·0
$(P_1 - P_2)/n$ =	$\cdot 0_2 43$	$\cdot 0_2 49$	$\cdot 0_2 51$

The value of $l - k$ for NaCl is $+0{\cdot}01424$ and for KCl $+0{\cdot}01316$, while a glance at the first table (p. 221) shows that the ionisation coefficient of solutions of the former salt falls off with the concentration somewhat more rapidly than, indeed for some concentrations, about twice as rapidly as, in the case of the latter. There cannot, therefore, be a close approximation to constancy in the absolute values of $(P_1 - P_2)/n$, but as these values are comparatively large, the percentage difference between them is comparatively small.

For the thermal expansion of these salts we have from Bender's observations,

For n =	1	1·5	2	2·5
$(P_1 - P_2)/n$ =	$\cdot 0_3 108$	$\cdot 0_4 85$	$\cdot 0_4 815$	$\cdot 0_4 78$

The value of $l - k$ in this case for NaCl is $+ 0{\cdot}0_3 91$, and for KCl $+0{\cdot}0_2 13$. There is thus a closer approximation to equality in the values of $(l - k) \Delta\alpha / \Delta n$ for the two salts, for thermal expansion than for density. Accordingly the absolute differences in the values of $(P_1 - P_2)/n$ are smaller than in the case of density. But as the values themselves are much smaller, the differences between the values when expressed as percentages of any one of the values are greater. And thus the approximation to constancy, of $(P_1 - P_2)/n$, in the case of thermal expansion is not so great as in the case of density, when judged in this way.

For viscosity $l - k$ for NaCl is $-0{\cdot}0022$ and for KCl $-0{\cdot}0028$. The values of $(l - k) \Delta\alpha / \Delta n$ will thus be less nearly equal than in the case of the thermal expansion and the differences between the values of $(P_1 - P_2)/n$ will be somewhat greater. As the $(l-k)$'s in this case, however, are more than twice as great as in the case of thermal expansion, the differences in the values of $(P_1 - P_2)/n$, if expressed as percentages of one of them, will be smaller than in the case of thermal expansion. Accordingly we find from Brückner's observations,

---

§ Wied. *Ann.*, liii, (1894), p. 14.

For n =	0·5	1·0	1·5	2·0	2·5
$(P_1 - P_2)/n$ =	$\cdot 0_2116$	$\cdot 0_2122$	$\cdot 0_2126$	$\cdot 0_2128$	$\cdot 0_2135$

For surface-tension $l-k$ for NaCl is $-0{\cdot}096$ and for KCl $-0{\cdot}116$. The approximation to constancy (judged by the percentage criterion) will thus not be so close as in the last case. Rother's observations give, by graphical interpolation,

For n =	1·0	1·5	2·0
$(P_1 - P_2)/n$ =	·016	·0113	·0105

For refractive index $l-k$ for NaCl is $+0{\cdot}0054$ and for KCl $+0{\cdot}0091$. Thus the values of $(l-k)\,\Delta\alpha/\Delta n$ for the two salts are much more nearly equal than in the case of the other properties and consequently the differences in the values of $(P_1 - P_2)/n$ will be smaller than in the case of the other properties. Bender's observations give for the D line,

For n =	1·0	2·0	3·0
$(P_1 - P_2)/n$ =	$\cdot 0_329$	$\cdot 0_317$	$\cdot 0_324$

If the value for $n=2$ be omitted from consideration, as being probably in error, $(P_1 - P_2)/n$ is seen to be more nearly constant so far as absolute magnitude is concerned than in the other cases considered. As the values of $(P_1 - P_2)/n$ however, are small, their differences when expressed as percentages are comparatively large, and the approximation to constancy, viewed in this way is less than, *e. g.*, in the case of density.

The above account of this phenomenon may be further tested by the aid of Kohlrausch's observations of electrical conductivity; for in this case $l-k$ is the molecular conductivity at infinite dilution (usually written μ_∞). The following values of differences of molecular conductivity will be sufficient :

n	$(P_1 - P_2)/n$ FOR CONDUCTIVITY.			
	HCl and NaCl.	HCl and $\frac{1}{2}K_2CO_3$	$\frac{1}{2}H_2SO_4$ and Ag No$_3$	Ag NO$_3$ and Na Cl.
0·01	2454	2333	1838	+ 55
0·1	2379	2365	1198	+ 21
0·5	2260	2289	1171	− 29
1·0	2085	2120	1185	− 60

Compare with this the following table of values of μ_∞ and α :—

n	IONIZATION-COEFFICIENTS (α).				
	HCl $\mu_\infty = 3500$.	NaCl $\mu_\infty = 1030$.	$\frac{1}{2}K_2CO_3$ $\mu_\infty = 1400$.	$\frac{1}{2}H_2SO_4$. $\mu_\infty = 3700$.	$AgNO_3$. $\mu_\infty = 1090$.
0·01	·976	·934	·773	·772	·933
0·1	·927	·840	·628	·563	·794
0·5	·862	·735	·520	·513	·668
1·0	·794	·675	·471	·492	·582

The approximate constancy holds in the case of HCl and $\frac{1}{2}K_2CO_3$, because μ_∞ for HCl being more than twice as great as for $\frac{1}{2}K_2CO_3$, α for the latter falls off nearly twice as rapidly as for the former. In the case of $AgNO_3$ and NaCl there is no approximation to constancy, because the values of μ_∞ being nearly equal, the rates at which α varies with n are very unequal.

THE INDEPENDENCE OF THE CONTRIBUTIONS MADE TO THE VALUE OF A PROPERTY BY THE FREE IONS.

The constant l for a salt ap will, according to the dissociation conception, be composed additively of two parts, l_a and l_p, pertaining to the ions a and p respectively, and these constants

l_a and l_p will be characteristic of the ions and will not depend upon the salt from which they have been dissociated. A certain amount of evidence has been accumulated which may be said to point in this direction. In the case of several properties it has been shown that for solutions of considerable dilution, the difference between the values of the property for solutions of two salts (*ap* and *bp*) having a common ion and the same molecular concentration, is independent of what the common ion may be; and the value of the difference divided by the number of gramme-equivalents per litre of the salts in solution has been taken to be approximately the difference between the constants l_a and l_b. Results of this kind have been obtained by Valson and Bender for density and refracting power, by Kohlrausch for electrical conductivity, by Raoult for the depression of the freezing point, by Traube * for the change of volume on solution, by Röntgen and Schneider for compressibility, and by Jahn for the electromagnetic rotation of the plane of polarization.

Applying the above expression, we have for the difference in the values of a property per unit of molecular concentration,

$$(P_{ap}-P_{bp})/n=k_{ap}(1-a_{ap})-k_{bp}(1-a_{bp})+l_p(a_{ap}-a_{bp})+l_a a_{ap}-l_b a_{bp}, \quad (12$$

and at infinite dilution

$$(P_{ap}-P_{bp})/n=l_a-l_b. \quad \ldots\ldots\ldots\ldots \quad (13)$$

Had the experiments referred to been all carried out at extreme dilution, as were those of Kohlrausch, afterwards extended by Loeb and Nernst †, the evidence would be quite satisfactory. But in general they have been made at only moderate dilution, and it is obvious from (12) that the approximate independence of the common ion on the part of $(P_{ap}-P_{bp})/n$, may be quite consistent with considerable variation in l_a-l_b. It is clear that the first three terms of (12) may readily mask any variation in the last two, and that, if the last two did not vary, l_a-l_b could not in all cases be the same.

---

* *Ztschr. anorgan. Chemie*, iii. (1892), p. 1.

† *Ztschr. für phys. Chemie*, ii. (1888) p. 948.

That no satisfactory conclusion can be drawn from experiments of this kind, unless conducted at extreme dilution, may be shown roughly in the case of density by the aid of the results obtained above. For we may assume that the ionization-constants for density obtained above will not be very different from those which would be derived from observations made at greater dilution*. We know from Kohlrausch and Hallwachs's observations that if ap and bp represent NaCl and $\frac{1}{2}Na_2CO_3$ respectively, $(P_{ap}—P_{bp})/n$ will have the value $0·0139$ for solutions containing ·005 grm.-equivalents per litre, and that for NaCl and HCl it will have the value of $0·0235$. We may assume that for NaCl and KCl it will be about ·02. From the values of k for these salts we find the first two terms of (12) to be $·0_364$. If we assume l_p to have half the mean value of l for NaCl and KCl, the third term will amount to $—·0_498$. The first three terms thus amount to about $·0_354$, or say 3 per cent. of the value of $(P_{ap}— P_{bp}/n$. Thus, observations of the kind referred to, for density, could give no satisfactory result, even if conducted at this very great dilution. At a dilution of ·001 grm.-molecules per litre, the first three terms of (12), calculated in the same way, amount to $·0_31$, or about 0·5 per cent of $(P_{ap}— P_{bp})/n$. A proved independence of p at this dilution would be more satisfactory.

Observations at such extreme dilutions, in the case of most properties of solutions, are probably impracticable. But they are fortunately unnecessary for the settling of the question under consideration. For if the values of the ionization-constants for any property have been obtained as above from observations over a range extending to great, though not necessarily extreme, dilution, the values so obtained may fairly be assumed to apply very approximately to much greater dilutions; and from the values of l_a+l_p, l_b+l_p, l_a+l_q, l_b+l_q, etc., thus obtained, it may readily be determined whether or not $l_a—l_b$ is independent of the ions p, q, etc. Unfortunately, Kohlrausch and Hallwachs's observations on specific gravity are not sufficiently numerous for this purpose.

---

[*] Mr. E. H. Archibald, one of my students, tells me that for magnesium sulphate Kohlrausch and Hallwachs's data give $k = ·05663$ and $l = ·066387$.

THE DETERMINATION OF THE IONIZATION-CONSTANTS FOR THE FREE IONS.

The values of the constants l_a, l_b, l_p, etc., may probably, in some cases at least, be determinable in the following way: The experiments just referred to would give l_a+l_p, l_b+l_p, etc., as well as k_{ap} and k_{bp}, etc. If now, guessing at the value of l_p, we find the first three terms of (12) to be negligible at dilutions at which P_{ab} and P_{bp} can be determined with sufficient accuracy, determination of these quantities will give the value of $l_a\alpha_{ap}-l_b\alpha_{bp}$; and if a_{ap} and a_{bp} be known with sufficient accuracy, l_a, l_b, and l_p may then be found. It would of course be necessary to check our guess at the value of l_p by substituting the value found in expression (12) and seeing whether or not with this value the first three terms would be negligible.

II.—Some Analyses of Nova Scotia Coals and other Minerals.—By E. Gilpin, Jr., Ll. D., F. R. S. C., *Inspector of Mines, Halifax, N. S.*

(Communicated March 8th, 1897.)

I purpose this evening to give you a few analyses of Nova Scotia minerals which are of interest.

A set of analyses of Coals from the three seams worked at Springhill by the Cumberland Railway and Coal Company were given me some months ago. They are as follows, and taken from the workings at a depth of from 800 to 1000 feet:

East or No. 1 Slope—Black or Main Seam :

Moisture	2·02
Volatile combustible matter	18·94
Fixed Carbon	75·29
Ash	3·75
	100·00
Sulphur	1·14

West or No. 2 Slope—South Seam. Sample No. 1, from upper division of seam :

Moisture	1·41
Volatile combustible matter	27·93
Fixed Carbon	67·47
Ash	3·19
	100·00
Sulphur	·58

West or No. 2 Slope—South Seam, lower division of seam :

Moisture	1·51
Volatile combustible matter	28·44
Fixed Carbon	65·38
Ash	4·67
	100·00
Sulphur	·61

North or No. 3 Slope—North Seam :

Moisture	2·71
Volatile combustible matter	28·41
Fixed Carbon	64·69
Ash	4·19
	100·00
Sulphur	·79

Analyst—J. T. Donald, *Montreal.*

These analyses show the coals to be of excellent quality. The amounts of ash and sulpher are small, and that of the fixed carbon is large.

These analyses are interesting when compared with a set of analyses of the same seams made by me in the year 1881, and I believe not hitherto published, and with an analysis of the Black seam made by me in the year 1880, and published in the Transactions of the North of England Institute of Mining Engineers, in a paper on Canadian Coals, giving a full set of analyses of Nova Scotia coals, their ashes, etc.

The analyses made in the year 1881 are as follows :—

East Slope—Black or Main Seam :

Moisture	3·86
Volatile Combustible Matter, Fast Coking	35·65
“ “ “ Slow “	26·46
Fixed Carbon ....Fast “	59·90
“ “ ....Slow “	65·23
Ash	4·45
Specific Gravity	1·29
Theoretical Evaporative Power	8.858 lbs.

West Slope—South Seam :—

Moisture	1·399
Volatile Combustible Matter, Fast Coking	34·808
“ “ “ Slow “	31·225
Fixed Carbon ....Fast “	58·003
“ “ ....Slow “	61·586
Ash	5·790
Sulphur	·808
Theoretical Evaporative Power	8·46 lbs.

North Slope—North Seam :

Moisture	1·625
Volatile Combustible Matter, Fast Coking	33·401
" " " Slow "	28·672
Fixed Carbon ..Fast "	60·701
" " ..Slow "	65·431
Ash	4·272
Sulphur	·783
Theoretical Evaporative Power	8.99

The analysis of the Black seam made in the year 1878 has a complete sample column of coal representing the whole seam as then worked. A companion column was presented to the museum of the Geological Survey at Ottawa. The section of the seam was as follows :—

	Feet.	Inches.
Top coal, a little coarse	1	7
Coal, good	1	2½
Fire clay parting	—	0½
Coal, good	—	8
Coal, good	1	6
Fire clay parting	—	6
Coal, a little coarse	—	9
Coal, good	—	11
Fire clay parting	—	1
Coal, good	2	2
Coal, good, one inch soft	—	3
Coal, coarse	—	8½
Total	10	4½

I need not repeat here the minute description given then of the various layers. It may be stated that the coal of the sample was bright, with occasional calc-spar and pyrites films, with somewhat irregular fracture. In the vicinity of the point in the mine where the sample was taken a large amount of coal was beautifully iridescent, recalling that splendid mineral Chrysocolla. Samples of this when analysed with the means at my disposal did not give a reason for the coloring. It may have been due to some process of oxidation of iron pyrites.

Each band of coal was analysed with the following results :

Band, No.		1.	2.	3.	4.	5.	6.	7.	8.	9.
Moisture		.98	.76	1 21	.30	.63	.90	1.34	.56	.41
Volatile Comb. Matter	Slow Coking	30.84	32.22	33 81	29.19	28.90	34.56	33.64	30.27	28.54
	Fast Coking	34.75	36 12	37.25	32 65	33.84	35.17	35.94	33.88	30.47
Fixed Carbon	Slow Coking	60.73	60.91	63.13	67.95	65.16	60.59	59.86	60.89	63 63
	Fast Coking	57.82	57.01	59.60	64.48	60.22	59.98	57.56	57.28	61.70
Ash		7 45	6.11	1.85	2.56	5.31	3.95	5.16	8.28	7.42
Sulphur		.85	.56	.79	1.21	1.85	.89	1.40	2.65	2.25
Specific Gravity		1.31	1.30	1.28	1.27	1.29	1.28	1.29	1.33	1.32
Theoretical Evap. Power	Slow Coking	8.33	8.40	8.65	9.28	8.92	8.32	8.20	8.35	8.99
	Fast Coking	7.95	7.65	8.20	8.83	8.30	8.20	7.88	7.75	8.54

Coke bright and tolerably compact.
Ash of average sample grey, with tinge of pink.

The average of the analyses calculating the respective thickness of the bands is about :—

Moisture		·78
Volatile Combustible Matter,	Slow Coking.	31·32
" " "	Fast "	33·45
Fixed Carbon	Slow "	62·54
" "	Fast "	59.53
Ash		5·34
Sulphur		1·38

The ultimate analyses of the coal gave :—

Carbon	78·51
Hydrogen	5·19
Oxygen Nitrogen	9·98
Sulphur	1·12
Ash	5·20
	100·00

As compared with the coal from other Provincial districts the Cumberland coals stand as follows :—

	Cape Breton.	Pictou.	Cumberland.
Moisture	·75	1·19	1·86
Volatile Combustible Matter	37·26	29.10	26·76
Fixed Carbon	58·74	60·63	66·65
Ash	3·25	9.34	4·70

From a comparison of the later with the older analyses it will be seen that those of coal from the deeper portions of the seams show lessened amounts of volatile combustible matter, increased percentages of fixed carbon, and diminished amounts of sulphur and ash. Speaking in general terms the coal would appear to have developed more into a steam fuel, the evaporative power being in a general way proportionate to the percentage of fixed carbon.

This would give the coals as at present mined a high calorific power. From analyses by Mason and Matheson in a paper read before the Nova Scotia Mining Society, it would appear that the calorific powers of coals from the Sydney coal fields vary from 7238 to 7623; of Pictou coal (sample from Intercolonial mine) 6963; and of Springhill coal 7898.

As compared with United States coal they should stand nearly in the rank of the best free burning coals of Pennsylvania, Virginia, and Maryland. Those coals hold from 12 to 21 per cent of volatile matter, and from 69 to 76 per cent of fixed carbon. The average contents of the United States coals are from 29 to 35 per cent of volatile matter and from 53 to 67 per cent of fixed carbon. These coals therefore from Springhill should rank for steam purposes next to the class which may be described as the best selected for use on the large ocean passenger vessels.

I have not at hand any proximate analyses of English coals to compare with these under consideration. However, taking the results obtained in the English Admiralty trials of steam coals, and comparing the percentage of fixed carbon found in the trials with the fixed carbon given in these analyses, it will be found that the English and Scotch coals run from 49 to 88 per cent as compared with 68.2 per cent in the Springhill coals.

This would give the Springhill coal about the same relative position to the best Welsh coals as has already been assigned to it in comparison with the best American coals. The evaporative power of the Springhill coals would, from the analyses, stand higher than that of the English and Scotch coals, and rank next to that of the best Welsh steam coals. It may be remarked that the best American and Welsh coals would be classified as free burning, semi-anthracite, while the Springhill coals are bituminous and coking.

I also give here an analysis of the Patrick seam as worked on the Patrick Lease, now the property of the Canada Coals and Railway Company, on the west bank of the Macan River. The sample is from the lower part of the seam :—

Moisture	1·00
Volatile Combustible Matter	55·61
Fixed Carbon	35·60
Ash	7·49
Sulphur	·50

As reddish and pulverulent.

The following analyses of pit waters may be given here :—

Vale Colliery :—

Water contained in 1000 parts.

Sulphate of Lime	·514
" Magnesia	·100
Silicious matter	·190
Chloride of Sodium	1·452
Carbonate of Sodium	7·509
Iron and Alumnina	Trace.
Organic matter	Trace.

No free acid.

Springhill, from feeder 1300 feet level, water clear, free from smell, slightly acid :—

Sulphuric Acid, free	Trace.
Sulphate of Lime	Large.
" Magnesia	Small.
Chloride of Sodium	Considerable.
Carbonic Acid	Small.
Carbonate of Lime	Small.
Iron Oxides	Small.

Water exerted slightly corrosive action on iron exposed to it for twenty-four hours.

A number of analyses of Nova Scotia mineral and pit waters are given in a paper by the writer, read before the Newcastle Mining Institute some years ago.

In the upper part of George's River in Cape Breton County there is a large deposit of iron pyrites in rocks which are, I think, laid down as Laurentian by the Geological Survey. The deposit has as yet been examined only superficially, but so far appears somewhat low in sulphur. The following analysis of samples from the most promising exposure gives :—

Sulphur	25·00
Copper	1·10
Gold	Trace.
Silver	Trace.
Silica	52·00
Iron, etc	25·00

For a number of years the presence of iron ore at Whycogomah in Cape Breton has been well known. The ores which are magnetites and red hematites are so very favourably situated, being close to the waters of the Bras d'Or Lake, that a good deal of work was done on them a number of years ago. A number of beds were opened and traced. They varied up to nine feet in thickness, and occurred in the Limestone division of the Laurentian, as described by Mr. Fletcher in his numerous reports on the Geology of Cape Breton, issued by the Survey.

The analyses of the ores were contradictory in character, some being high in phosphorus, while others were very pure and ran high in iron. Last fall fresh discoveries were made in this district some distance from the old openings, of beds of magnetite some upwards of 100 feet in width. Indications are not wanting that these ores extend over a large tract of country.

The following analyses will serve to show the quality of the ores :—

Silica	14·41
Alumina	7·33
Manganese Oxide	·61
Lime	3·00
Sulphur	·22
Metallic Iron	54·50
Phosphorus	Trace.
Magnesia	Trace.

Iron.	Phosphorus.	Sulphur.
55·70	None.	·68
59·60	·16	·23
63·20	·004	·31
54·30	·005	·38
53·20	·38	·25
50·74	·31	·024
53·12	·28	·026
52·85	·0058	·138

Silica	21·05
Ferric Oxide	53·54
Ferrous Oxide	21·24
Alumina	2·26
Manganese Oxide	·50
Lime	1·17
Magnesia	·36
Sulphur	·023
Phosphorus	Trace.
Metallic Iron	54.00

Metallic Iron	54·36
Phosphorus	·38

Silica	13·00
Metallic Iron	55·70
Sulphur	·68
Phosphorus	Trace.

These analyses show that there are ores in this vicinity valuable enough for shipment as regards quality, and the present owners consider that new explorations now being carried on will show that the ore is present in quantities sufficient to warrant working on a large scale.

In this connection reference may be made to this division of the Cape Breton Laurentian in which these deposits occur. It may be distinguished as the Limestone division, as it is distinguished mineralogically from the other, or felsite division, by the presence of numerous beds of limestone, in addition to the felsites, gneisses, granites, etc., common to both. These limestones furnish marble, as at West Bay and other localities, lime of excellent quality, and dolomites, suitable, as at New Campbellton, for furnace linings. Iron ores occur in them at numerous points both hematite and magnetite. Graphite is also found In all probability, phosphates, similar to those found in Quebec will be proved on search being made. Where these measures are cut by dykes, copper and lead ores carrying gold and silver occur, and may in some cases prove valuable. As yet so far as my information goes free gold has not been found in quartz in the limestone division. The gold of Middle River and Cheticamp appears to be associated with soft talcose and felsitic schists of the other division. This gold occurs at Middle River free in quartz, and in the river gravel, derived presumably both from the quartz and augmented by gold flakes from the schists. At the Cheticamp River, so far as can be judged from the work done, it would appear to have a similar source, and to be connected only with the felsite series. In the latter case part of the gold may be derived from mineralized zones adjoining the dykes cutting the various rocks. However, the explorations of the coming season will probably give us more exact information. It is interesting to note in connection with the occurrence of gold at Cheticamp that native silver occurs in the Mackenzie River a short distance north, and it is possible that explorations in that section may result in the discovery of important amounts of this metal and associated gold.

III.—NOTES ON NOVA SCOTIAN ZOOLOGY: NO. 4.—BY HARRY PIERS, *Halifax, N. S.*

(Read 12th April, 1897.)

In the following paper is recorded anything of interest regarding the zoology of the province that has come to my notice during the past year or two. Former contributions on the same subject will be found in recent volumes of the Transactions of this Society.

MAMMALS.

GRAY SQUIRREL (*Sciurus carolinensis*). The capture of a specimen of this large species is recorded in a former paper of mine (vide *Trans. N. S. Inst. Nat. Sc.*, vol. vii., p. 467). Another was killed, May 20th, 1894, near the old sugar refinery, on the western side of the North-West Arm, Halifax.

RED FOX (*Vulpes vulpes* var. *fulvus**). In the winter of 1893-4, an albinistic Fox was killed at Musquodoboit, Halifax County, and was brought to Mr. A. G. Kaizer, furrier of this city, who subsequently sold it to Captain Campbell. The general colour of the pelt was cream white with a rusty tinge. Each hair of the tail was tipped with black, giving the whole brush the appearance of having been slightly singed. More of this black was towards the end and underside of the tail, but the extreme tip was whitish. Posterior parts of ears, black; but inside, white. Snout dusky. On the chest, a little behind the four legs, was a lead-coloured blotch which merged into the surrounding colour of the under parts. A white line margined with black extended on the front of the hind legs, from hock upward; front of hind legs, from hock to claws, black. Length of pelt from snout to tip of brush, four feet.

---

*Mr. Outram Bangs in a paper published in the *Proceedings of the Biological Society of Washington* (March 16, 1897), describes a new form of Fox from Nova Scotia under the name *Vulpes pennsylvanica vafra*, it being distinguished from the typical *V. pennsylvanica* (=*fulvus*) by its larger size and deeper colour. Mr. Bangs also considers the American Red Fox entirely distinct from the European species (*V. vulpes*).

Mr. Kaizer informs me that some years ago he obtained a similar skin. This and the specimen just described, are the only albino Red Foxes he has ever seen, although he handles very many pelts.

Regarding the Silver Fox (var. *argentatus*), a well-known variety of the Red Fox, Mr. Kaizer tells me that while it is found on the Island of Cape Breton and in the eastern and western parts of Halifax County, and sometimes also in Guysborough, yet he has never for thirty years heard of its capture west of the County of Halifax. He is therefore inclined to think it is somewhat local in distribution.

Birds.

Roseate Tern (*Sterna dougalli*). On June 2nd, 1894, Mr. T. J. Egan obtained a specimen which had been shot at Prospect, Halifax County, N. S., a day or two before.

Mallard (*Anas boschas*). A male was shot at Cole Harbour, Halifax County, on October 17th, 1895, and was brought to Mr. W. A. Purcell. Another, killed at the same place, was in the Halifax market on November 2nd, of that year. It had evidently been taken two or three days before. The Mallard is a rare Nova Scotian bird.

Wood Duck (*Aix sponsa*). Mr. Purcell informs me that a male Wood Duck was shot several miles westward of Halifax (at Joshua Umlah's) about September 18th, 1895, and another was taken about the same date near Three Fathom Harbour.

King Eider (*Somateria spectabilis*). A fine specimen, a male, of this rare winter bird was killed on February 22nd, 1895, at Devil's Island, at the mouth of Halifax Harbour. Another male was taken at Three Fathom Harbour, Halifax Co., about March 20th, of the same year. Both birds were brought to Mr. Purcell. One or two other specimens were in the Halifax market about the last-mentioned date.

Least Bittern (*Botaurus exilis*). In March, 1896, a bird of this species was brought to me for identification. I examined it "in the flesh" and found it to be an adult male in full breeding plumage; total length, 14 ins.; wing 4.70; bill 1.88. It had been shot by Thomas Beck on the 16th of the above mentioned month, at Upper Prospect, Halifax County.

This small, handsome species has never before been met with in Nova Scotia, and its occurrence here is remarkable. Its regular range in the east only extends as far north as Massachusetts, but stragglers have been taken in Maine and New Brunswick. In the latter province some five individuals were shot between 1877 and 1881, on the Bay of Fundy shore between Black River and Mispeck (Chamberlain, "Catalogue of Birds of New Brunswick"). In Ontario, Mr. McIlwraith reports it as generally distributed throughout the south part of the province, and as a regular summer resident at Hamilton Bay (*Birds of Ontario*, 2nd ed., p. 108.) Its presence in Nova Scotia is the more remarkable when we consider the very early period of the year in which it was taken; a time when only the more hardy birds arrive here.

LITTLE BLUE HERON (*Ardea cœrulea*). On March 18th, 1896, a male of this species, in adult plumage, was killed at Lawrencetown, Halifax County. The bird was thin and had evidently had but little food for some time. It was brought to Mr. Egan. On April 10th, 1897, another specimen, an adult, was taken at Sheet Harbour. It was mounted by Mr. Egan and now belongs to Mr. Hart of Halifax.

With these two exceptions, the species has only once been collected in the province. The late Mr. J. Matthew Jones reported that a specimen was taken at Cole Harbour, near Halifax, during the summer of 1884, (*vide* Chamberlain's *Catalogue of Canadian Birds*). The specimen referred to by Mr. Jones was formerly in the collection of Mr. Egan, but is now owned by the Fisheries Department at Ottawa. It was in whitish immature plumage.

PURPLE GALLINULE (*Ionornis martinica*). This handsome but somewhat bizarre species is an accidental visitor in Nova Scotia. Two specimens have been taken in the province in previous years, one having been killed near Halifax on January 30th, 1870 (Jones, *American Naturalist*, iv., 253), and another captured in April, 1889 (vide *Trans. Inst. Nat. Sc.*, vii., 468). It not unfrequently comes as far north as the New England States, but in Canada has only been reported from our own province, New Brunswick and Ontario, in all of which localities its occurrence is merely casual.

In 1896, I saw a adult female which had been captured alive on Devil's Island, Halifax Harbour, about January 16th of that year, the bird had evidently struck the lighthouse on the island and fell to the ground disabled. It was kept alive for about twenty-five days when it died and was mounted by Mr. Walter Brett. S. Fraser of Halifax, who now possesses the bird, also has another of the same species, which he tells me was found dead at Chezzetcook, Halifax County, in the same week as that in which the above-mentioned specimen was taken.

WILSON'S SNIPE (*Gallinago delicata*). About October 11th, 1894, there was shot at Canning, King's County, a Snipe whose colours were so very light and tinged with gray, as to constitute partial albinism. It was mounted by Mr. Purcell for Mr. Dickie, of Canning. On December 3rd, 1894, I noted a Snipe at Halifax—the latest date on which I have seen the species. There was about five inches of snow on the ground at the time. The last Snipe of the regular body was noted on November 21st of that year. I have been told that individual birds occasionally remain very late in the season.

LAPWING (*Vanellus vanellus*). This is another purely accidental visitor in our province. The species is a native of the northern portions of the eastern hemisphere, although it occasionally has braved the perils of the Atlantic and been found in Greenland.

On March 17th, 1897, an individual of this species was found, lying dead, on the sand of the shore at Ketch Harbour, near Halifax, N. S. It was very thin and death had evidently been largely owing to starvation. The bird was brought to Mr. Egan's store, where I examined it before it was skinned.

It is doubtful if there is another well authenticated record of the occurrence of this bird in temperate America, for Mr. Ridgway in his Manual places a query after "Long Island" in the list of localities where it has been met.

MOURNING DOVE (*Zenaidura macroura*). Several Mourning Doves were taken in Halifax County during October, 1896. Mr. Searle, taxidermist, had three specimens: one killed about October 2nd; another shot at Terence Bay, about October 6th; and a third killed about the 9th. I also saw a fourth specimen in the market on October 10th, which had been killed at Porter's Lake, probably the day before. Mr. Francklyn of Halifax purchased a specimen in the market on September 28th, 1895. It had likely been killed on the previous day. Still another specimen was shot at Canning, N. S., by C. R. Dickie, on November 4th, 1895.

BLACK VULTURE (*Catharista atrata*). On January 12th, 1896, a Black Vulture was killed at Pugwash, Cumberland Co., N. S., and two days later was brought to Mr. Egan. I examined it after it had been mounted and identified it as the above species. It measured as follows: wing 17.75 ins., tail about 7.50, culmen .93, tarsus 3.13, middle toe without claw 3.

The occurrence of this bird in our limits is remarkable, and is doubly so when we consider the period of the year in which it was taken. It is regularly found as far north as North Carolina, and has been met as a casual visitor in the New England States, and Chamberlain (Nuttall's *Ornithology*, 1891,) records that it has even been killed on Grand Manan in the Bay of Fundy. With this exception, it has not hitherto been met with in Canada.

BROAD-WINGED HAWK (*Buteo latissimus*). In September, 1894, Mr. Purcell showed me a hawk which I identified as a young bird of the above species. It had been shot at Windsor,

N. S., on the 9th of the month. The species is very rare about Halifax, although in some portions of the Maritime Provinces it has been reported rather common. The bird is evidently local in distribution.

Duck Hawk (*Falco peregrinus anatum*). About 1893, Mr. Austen mounted an adult male which had been killed on Devil's Island, at the mouth of Halifax Harbour. The bird is very rare in Nova Scotia. Two individuals were taken on McNab's Island in September, 1892, as recorded in "Notes on Nova Scotian Zoology, No. 3."

American Hawk Owl (*Surnia ulula caparoch*). This owl has now become rare in the province. In the winter of 1895, Mr. Purcell had four specimens—a most unusual number: a pair purchased in the Halifax market on November 16th, probably from near Musbuodoboit; one brought in, November 23rd, by John Paul, Indian, who had killed it near Salmon River, Halifax County; and another brought to town on December 2nd, from West Chester where it had been taken. All were quite fresh and had evidently been shot only a day or two before.

Pileated Woodpecker (*Ceophlœus pileatus*). A female was shot at Liverpool, N. S, on October 17th, 1895; another female was taken on the Windsor Road, Halifax County, about November 3rd, 1896; a male was brought to Mr. Purcell on January 6th, 1897; and a fourth specimen was killed at Oxford, Cumberland Co., about February 10th, 1897.

American Crow (*Corvus americanus*). A curious freak of nature is found in a partially albinistic Crow which was shot at Shad Bay, Halifax Co., on October 6th, 1896. It agreed perfectly with descriptions of normal individuals except in the colouring, which may be more particularly described as follows: general colour brown (umber brown or light hair-brown), darker on throat, cheeks and belly; scapulars and feathers of back margined obscurely with whitish; primaries mostly whitish; tertials white; tail feathers light reddish brown (cinnamon rufous) margined with whitish on outer edge; legs and bill dark-brown; eyes brown. Measurements: wing, 12.90 in.; tail, 7.50; exposed culmen, 1.93; depth of bill at base, .92; tarsus, 2.37.

BOBOLINK (*Dolichonyx oryzivorus*). As is well known, this bird is now exceedingly rare at Halifax, although formerly it was rather common. On the marshes in the western parts of the province it is still very abundant. On May 20th, 1895, while walking past a field in the western part of Halifax, my ears were saluted by the rollicking, gurgling notes of a Bobolink, and I saw a fine male in full plumage sitting on the top rail of a fence. His notes brought to my mind the flat, diked lands of Grand Pré and Windsor. I went over a wall after him and soon he flushed out of the wet grass and in full song flew to the top-rail of a neighbouring fence, where he alternately pruned his feathers and sang his glorious song. This ditty begins with a few metallic notes, somewhat bell-like in tone, from which the singer proceeds helter skelter into an inimitable rush of liquid, light-hearted music.

On May 28th, 1897, I heard another Bobolink singing in a swampy bit of grass-land on the side of Chebucto Road, near the North West Arm, Halifax.

In May, 1896, my friend Mr. Walter Brett, of Sackvllle, N. S., showed me a specimen which he had collected at that place. He also informs me that during the spring he saw two males: one at Sackville and the other on the Bedford rifle-range. Still another, a young male, was taken by him on September 13th, 1897. It therefore is evident that the bird is found occasionally on the meadows bordering the Sackville River.

MEADOW LARK (*Sturnella magna*). On October 24th, 1895, a Meadow Lark was obtained by Mr. Dickie, of Canning, King's Co. The bird is very rare in this province.

BRONZED GRACKLE (*Quiscalus quiscala æneus*). On November 9th, 1894, one of these Grackles was shot on the Preston

Road, about two miles from Dartmouth, by Mr. Watson L. Bishop. There was about four inches of snow on the ground. It is the first of the species he has obtained, although he had collected for many years near Kentville, in the western part of the province. About Pictou, I understand, the species is more common, but near this city it is rare.

NORTHERN SHRIKE (*Lanius borealis*). This is a rare winter visitor in Nova Scotia. Mr. Francklyn shot a specimen at the North West Arm, Halifax, on February 22nd, 1895. The bird at the time was engaged in killing Snowflakes (*P. nivalis*). Another was obtained at Canning, King's Co., on March 1st of the same year, by Mr. Dickie.

BAY-BREASTED WARBLER (*Dendroica castanea*). In a previous article ("Notes on N. S. Zoology, No. 2") I noted a nest and two eggs of this warbler which had been collected by Mr. Austen. The same gentleman informed me that during the summer of 1895 he found two more nests at Dartmouth, near Halifax. One of these, containing four eggs, was taken during the latter part of June, and the other was collected about July. Nests and eggs of this species are rare.

BLACKBURNIAN WARBLER (*Dendroica blackburniæ*). During the summer of 1896 Mr. Walter Brett, of Sackville, Halifax County, took one specimen at that place. The late Mr. Downs considered this species very rare. Mr. Chamberlain thinks its secluded habits may have given rise to its reported rarety in Canada.

WINTER WREN (*Troglodytes hiemalis*). An account of the very rare nest and eggs of this wren has already appeared in the publications of the Institute (*Transactions*, vol. viii., p. 203). On June 11th, 1894, my brother and myself found another nest of the species at the Rocking-stone (Kidston's) Lake, Spryfield, Halifax County. It was only a few feet away from the spot in which was situated the one described in the paper just referred to. As far as could be observed, the second nest was precisely like the first in form, construction and materials. Both were built in moss, which was constantly saturated with water trickling from the bank above and slowly flowing over the top of the stone upon which the moss grew. The present nest contained a number of young, which we could just reach with the tip of the finger. There is not the slightest doubt about identification, for one of the parent birds was seen entering and leaving the opening a number of times. It is quite likely that this nest was constructed by the same birds which built the one found in May, 1891.

RUBY-CROWNED KINGLET (*Regulus calendula*). Mr. Austen, to whose exertions we owe much of our knowledge of the eggs and nest of this little bird, found two more nests at Dartmouth during the month of June, 1895. One of these contained eleven eggs, the other seven. Both were suspended beneath the limbs of black spruces. He tells me that nests of both the Ruby-crowned and Golden-crowned Kinglets may be found either on the limb or suspended beneath, so that the situation of the nest does not decide to which species it belongs.

REPTILES.

RING SNAKE (*Diadophis punctatus*). On July 24th, 1896, Mr. Augustus Allison saw one of these very rare snakes in Point Pleasant Park, Halifax, but he was unable to capture it. As well as he could judge, it measured about 10 or 11 inches in length. On the 17th of the succeeding month, on passing near the same place, he picked up a snake that had been crushed by a wheel. It proved to be *D. punctatus*. He kindly lent me the specimen, which I examined after it had been in alcohol for about a day. It furnished the following description: back, bluish black with slightly violet reflections in some lights. Beneath, orange buff, deepest about anus, palest on throat. Occipital stripe two scales wide, yellowish orange (nearly as deep in colour as abdomen near anus). Blackish spots on centre of each abdominal scutellum from near throat to near anus. These spots are small and round on anterior part of body, transversely longer on posterior part. Lateral ends of each abdominal scutellum with a blackish, somewhat triangular mark. Length, 14.25 inches; tail, 3.70; greatest diameter of body, .30. Fifteen rows of dorsal scales.

TRUNK-BACK or LEATHER TURTLE (*Dermochelys coriacea*). The occurrence of this animal in Nova Scotian waters has only once been previously recorded. In my "Notes on N. S. Zoology [No. 1]", was described a specimen which had been taken near Prospect, N. S., about August 30th, 1889.

In 1894 I had an opportunity of examining a second one, which had been taken on September 9th of that year by a man named Dauphiney, who found it entangled in his mackerel net about three miles off Hubbard's Cove, St. Margaret's Bay, to the westward of Halifax. It was brought to land and kept alive until September 13th, when it died, and was taken to Halifax for preservation. Subsequently it was placed on exhibition. The following measurements were taken after the reptile had been stuffed, and consequently a few of them are only approximately accurate: total length, 86 inches (7 ft. 2 ins.); length of head, 10 ins.; greatest breadth of head, 8¾ ins.; breadth between orbits, 4 ins.; length of fore-paddles, 32 ins. (*plus* about 2 ins., which had been worn off); greatest breadth of fore-paddles, 11 ins.; length of hind-paddles, 14 ins.; greatest breadth of hind-paddles, 10½ ins.; length of tail (may have been extended in mounting), 12 ins.; length of dorsal shell or carapace, 58 ins.; breadth of dorsal shell, 34 ins.; depth of notch in posterior margin of hind-paddles, about ½ in. The furrows or grooves in the shell were not so deep as those in the specimen of 1889. This is probably owing to a difference in age.

On August 16th, 1895, another of these turtles was captured off the same place (Hubbard's Cove) and was brought to a fish-dealer in this city. I examined it on August 20th while it was alive in a tank of water. As the animal was moving about, it was difficult to obtain exact measurements, but the following are very nearly accurate. Total length, 75 ins. (6 ft. 3

ins.); length of head, 10 ins.; breadth of head between orbits, 4 ins.; length of fore-paddle, 34 ins.; length of dorsal shell or carapace, 52 ins. This last measurement, however, does not include about six inches of the posterior point of the carapace, which had apparently been broken off. Each hind-paddle had a well-defined notch, about one inch deep, on the posterior margin. Such a notch was observed in the specimens taken in 1889 and 1894. In the present individual there was a hole, about an inch long, through the left fore-paddle. This was probably an old wound, for there was no indication that the turtle had ever been secured thereby.

The Trunk-back is a wandering species, whose presence on our coast is entirely accidental.

FISH.

SUNFISH (*Mola mola*). This is a rare visitor to our coasts. Only two specimens have been previouly recorded—one by the late Dr. Gilpin and the other by the present writer. On July 18th, 1894, one was captured by a man named Reino, about ten miles off Devil's Island, at the mouth of Halifax Harbour. It was brought to Halifax, where I examined it, and found that it differed only in size from the one taken in August, 1889. The length of the present specimen from tip of snout to end of most remote digitation of tail, was about 53.50 inches. From tip of dorsal fin to tip of anal fin it measured 67 inches. There were about ten scallops or digitations on the tail. Several parasites (*Pennella filosa ?*) had penetrated the sides of the fish in like manner to those noted in the specimen of 1889.

On August 14th, 1895, while on the shores of Bedford Basin with my brother, we noticed a black object appearing and disappearing on the glassy surface of the water about half a mile from shore. From the peculiar motion and form of the object it was recognized as the dorsal fin of a Sunfish. The animal was watched for some time as it rolled its fin out of the water and then back again, meanwhile progressing very slowly. It was evidently basking on the calm, warm surface. At times we thought another fin could be seen above the surface at a little distance from the first one ; and if this was so, a second fish must have been present. Finally we obtained a boat and rowed out to the bobbing black fin. The boat was put alongside the animal, which made no attempt to escape. It was lying on its side at the surface, a yard or two from us, and in full view. We estimated its length to be about 5½ feet, and it did not differ in shape from former specimens. It showed no alarm until struck with a pole, when it slowly sank, turned over, and propelled itself away beneath the surface by lateral movements of the dorsal and anal fins. It soon came up and once more waved its dorsal in the air. On being touched, it again went out of sight, but soon re-appeared and then sank once more. Finally the fin rose out of the water not far away and we pulled alongside. The animal, however, was now more alarmed, and on being merely lightly touched with an oar, turned over and, more rapidly than before, made off in an oblique direction downward. It was beneath for some time, and then appeared close to the shore, but was very shy and disappeared as soon as approached. A little later a wake was seen on the surface of the smooth water, progressing with a good deal of rapidity. It was without doubt caused by the fish swimming a little beneath the surface. It made toward the shore and then sheared off and went close along the beach, but in deep water, and then finally disappeared.

BATRACHIANS.

RED EFT (*Diemyctylus viridescens* = *miniatus*). The viridescent form of this species has been reported in the province by Dr. MacKay and myself, but the red, immature land form (*miniatus*) has not previously been collected. About October 10th, 1896, however, a red terrestial specimen was taken at Lakeview, near Bedford, by Miss M. H. King, and was brought to me for identification.

Up to a few years ago these young specimens had been a great enigma to scientists. The red form is so different in coloration from the older, viridescent one, that it was originally considered an entirely distinct species under the name *miniatus*, and even at one time was placed in a different subgenus. The late Prof. Cope in 1859 expressed the opinion that *miniatus* was only a state of *viridescens*, but it was not till a number of years later that the whole process of transformation from immature to mature pigmentation was observed in captive animals and fully described. The red specimens are found upon land, whereas the viridescent, full-grown form is aquatic in habits.

IV.—PHENOLOGICAL OBSERVATIONS, CANADA, 1896. COMPILED BY A. H. MACKAY, LL. D., *Halifax.*

(Read 10th May, 1897.)

I present here, in tables A and B, the observations made at twenty-two stations throughout Canada. The Province of Nova Scotia has by far the largest representation as usual; but that is not remarkable, as the observations were commenced in 1892 at Nova Scotia stations alone. In 1893 four New Brunswick stations were added. In 1894 the stations were extended to Winnipeg, and in 1895 to Vancouver.

In addition to the Dominion tables referred to, I give as a sample of problems which may be solved by an annual series of such tables, one showing the average date for five years of the first appearance of twenty objects in the Province of Nova Scotia. When these tables become fuller, as they promise to do in the future, averages for each station during a term of years would give interesting normals for each station for the comparison of the variations of climate from year to year. The comparison of the normals of each station throughout a province would be even more interesting. The publication of these tables will put all such data at the disposal of those wishing to utilize them for general or local purposes at present or in the future.

I expect this summer to have such reports from very many stations in Nova Scotia, as a great many of the public schools are making observations on a list of 100 objects in their respective stations in every quarter of the Province.

STATIONS AND NAMES OF THE OBSERVERS, 1896.

Nova Scotia.

Yarmouth, Yarmouth Co.—Miss Antoinette Forbes, B. A.
Berwick, Kings Co.—Miss Ida Parker.
Maitland, Hants Co.—Miss Bertha B. Hebb, B. A.

Halifax, Halifax Co.—Mr. Harry Piers.
" " Mr. G. M. Johnstone MacKay.
Amherst, Cumberland Co.—Principal E. J. Lay.
New Canaan, Cumberland Co.—Miss Sarah C. Ross.
River Philip, Cumberland Co.—Miss Jean McLeod.
Wallace, Cumberland Co.—Miss Mary E. Charman.
Pictou, Pictou Co.—Mr. C. L. Moore, B. A.
" " Mr. C. B. Robinson, B. A.
New Glasgow, Pictou Co.—Miss Maria Cavanagh.
Antigonish, Antigonish Co.—Prof. D. M. MacAdam.
Port Hawkesbury, Inverness Co.—Mrs. Louise Paint Forsyth.

Prince Edward Island.

Charlottetown, Queens Co.—Principal John MacSwain.

New Brunswick.

Saint John, St. John Co.—Geo. U. Hay, M.A., Ph. B., F. R. S. C.
Richibucto, Kent Co.—Miss Isabella J. Caie.

Ontario.

Niagara Falls, Welland Co.—Mr. Roderick Cameron.
Beatrice, Muskoka Co.—Miss Alice Hollingworth.

Manitoba.

Reston, Dennis Co.—Mr. H. B. MacGregor.

Assiniboia.

Pleasant Forks—Mr. Thomas R. Donnelly.

British Columbia.

Vancouver City, High School—Mr. J. K. Henry, B. A.

TABLE A.

PHENOLOGICAL OBSERVATIONS, CANADA, 1896.

Number.	Day of the year, 1896, corresponding to the last day of each month. January......... 31 July.... ......213 February .... 60 August ....244 March .... 91 September.....274 April...... .... 121 October........305 May ....152 November..... 335 June ....182 December..... 366	Yarmouth, N. S.	Berwick, N. S.	Maitland, N. S.	Halifax (P), N. S.	Halifax (M), N. S.	Average Southern Nova Scotia	Amherst, N. S.	New Canaan, N. S.	River Philip, N. S.
1	Alder, shedding pollen...............	106	102	...	110	..	106·0	111	...	111
2	Aspen, shedding pollen..............	...	123	...	...	...	123·0	114	...	111
3	" leafing out	...	139	...	144	...	141·5	...	..	...
4	Spring Anemone, flowering...........	...	.	...	...	...	.....	..	..	...
5	Red Maple, flowering	106	125	..	117	...	116·0	126	...	..
6	Hepatica, flowering..................	..	...	..	..	...	.....	...	...	...
7	Adder's Tongue Lily, flowering	...	...	...	...	...	.....	...	126	...
8	Mayflower, flowering.................	82	103	100	102	103	98·0	96	...	109
9	Dandelion, flowering	116	135	129	131	130	128.2	130	131	...
10	Salmon-Berry, flowering............	..	...	...	...	...	.....	..	...	...
11	" " fruiting........... ...	...	...	.	...	...	.....	...	...	...
12	Negundo, flowering..................	...	...	...	...	...	.....	...	..	...
13	Strawberry, flowering......	122	125	123	137	130	127·4	128	128	125
14	" fruiting.................	151	157	...	..	...	154·0	170	175	161
15	Prunus Americana, flowering.........	...	..	...	...	...	.....	...	...	...
16	Cherry (cultivated), flowering.........	..	137	...	...	...	137·0	141	152	...
17	" " fruit	...	...	...	.	...	.....	...	...	...
18	Wild Red Cherry, flowering....... ...	147	141	..	144	146	144·5	. .	139	138
19	Indian Pear (Amelanchier), flowering..	140	138	...	144	137	139·7	141	143	...
20	" " " fruiting...	...	..	...	...	...	.....	...	...	...
21	Blackberry (Rubus ?), flowering.......	...	...	...	..	. .	.. ..	143	174	...
22	Apple (cultivated), flowering..........	143	153	...	152	...	149·3	149	152	145
23	Western Dog-wood, flowering........	...	...	...	...	...	.....	...	..	...
24	Oaks, flowering...	...	...	...	162	...	162·0	...	...	...
25	Hawthorns (Crataegus) flowering	165	...	...	166	...	165·5	...	...	161
26	Lilac (cultivated), flowering	154	157	. .	162	157	157·5	162	...	159
27	Raspberry (wild), fruit ripe	...	...	...	...	...	.....	...	...	...

TABLE A.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, 1896

Number.	Wallace, N. S.	Pictou (M), N. S.	Pictou (R), N. S.	New Glasgow, N S.	Antigonish, N. S.	Port Hawkesbury, N S.	Average Southern Nova Scotia.	Charlottetown, P. E. I.	Saint John, N. B.	Richibucto, N. B.	Niagara Falls, O.	Muskoka, O.	Reston, Man.	Pheasant Forks, Assa.	Vancouver, B. C.
1	103	106	107	....	117	....	109·1	141	114	116	107	106	....	....	70
2	....	...	120	119	....	140	120·8	136	121	....	109	116	....	136	....
3	....	140	140	146	153	153	146·4	....	...	140	....	30	....	...	....
4	....	....	....	....	....	....	.....	....	130	....	117	....	112	116	...
5	139	135	130	131	133	138	133·1	137	122	131	111	124	....	....	....
6	....	....	....	....	....	....	......	....	122	....	107	124	...	....	....
7	....	130	129	129	...	...	128·5	....	128	....	107	111	....	....	....
8	110	106	105	108	108	117	107·4	113	128	117	...	115	...	....	....
9	128	129	129	124	125	135	128·9	139	128	138	119	124	....	149	88
10	....	....	....	....	....	...	....	...	....	....	....	....	....	...	82
11	....	....	....	....	....	....	....	....	....	...	....	....	....	....	162
12	....	....	....	....	....	....	.....	....	....	....	116	....	133	....	....
13	130	130	131	125	132	138	129·6	....	130	127	123	132	144	134	102
14	160	167	....	....	171	174	168·3	..	183	172	145	161	180	186	150
15	....	....	....	....	....	....	....	....	....	....	126	....	141	....	....
16	142	144	....	149	158	157	149·0	....	....	146	118	....	....	....	107
17	188	....	....	206	....	223	205·6	..	....	204	153	....	....	....	....
18	....	149	....	151	153	....	146·0	159	143	145	....	130	....	....	126
19	....	140	140	141	148	152	143·6	....	136	144	118	124	138	150	128
20	....	....	....	....	....	223	......	...	....	208	....	....	...	196	...
21	....	....	....	....	154	173	.....	....	...	...	145	....	....	....	126
22	147	....	....	154	157	166	152·9	159	....	152	131	132	....	...	126
23	....	....	....	....	....	...	......	....	...	....	....	....	....	164	135
24	....	....	....	...	....	....	......	...	...	148	131	....	....	....	....
25	....	155	....	149	....	....	155·0	166	....	160	136	135	138	...	149
26	159	161	....	....	166	174	163·5	...	....	158	132	135	....	....	136
27	....	....	....	....	....	218	......	...	...	...	....	....	194	199	....

TABLE B.

PHENOLOGICAL OBSERVATIONS CANADA, 1896.

Number.	Day of the year, 1896, corresponding to the last day of each month January.......... 31 July ....213 February.......... 60 August........244 March............. 91 September....274 April...............121 October.......305 May ....152 November.....335 June...............182 December 366	Yarmouth, N. S.	Berwick, N. S.	Maitland, N. S.	Halifax (P), N. S.	Halifax (M), N. S.	Average Southern Nova Scotia.	Amherst, N. S.	New Canaan, N. S.	River Philip, N. S.
31	Spring Wheat, first sowing	....	....	....	....	....	....	....	....	....
32	" " flowering	....	....	....	....	....	....	....	....	....
33	" " harvesting	....	....	....	....	....	....	....	....	....
34	Last Spring Frost	....	146	....	....	....	146·0	144	....	....
35	First Autumn Frost	....	268	....	300	....	234·0	268	....	....
36	Opening of Still Lakes	....	....	....	....	....	....	104	....	....
37	Closing of Still Lakes	....	....	....	....	....	....	....	....	....
38	Opening of Rivers, Spring	....	....	....	....	....	....	....	....	....
39	Closing of Rivers in Fall	....	....	....	....	....	....	....	....	....
40	Thunderstorms	....	....	....	....	....	....	....	100	....
		....	....	....	....	130	....	139	140	....
		....	....	....	....	144	....	....	143	....
		....	173	....	....	172	....	172	172	....
		....	....	....	....	174	....	....	173	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	212	....	....
		....	222	....	....	....	....	222	....	....
		....	....	....	....	....	....	....	....	....
		....	232	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
41	Droughts affecting Vegetation	....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....
42	Song Sparrow, first appearance	....	95	97	*74	103	....	98	....	....
44	American Robin, Eastern	....	83	95	*104	103	....	92	....	....
45	Merŭla propinqua, Western	....	....	....	....	....	....	....	....	....
48	Junco, Eastern species	....	104	....	104	....	....	116	....	....
49	" Western species	....	....	....	....	....	....	....	....	....
50	Red-Winged Blackbird	....	....	....	....	....	....	....	....	....
51	Spotted Sandpiper	....	137	....	105	....	....	....	....	....
52	White-bellied Swallow	....	126	109	117	....	....	101	126	....
53	Meadow Lark	....	....	....	....	....	....	....	....	....
54	Kingfisher	....	....	....	....	....	....	120	....	....
55	Hummingbird, first appearance	....	138	....	136	....	....	143	140	....
56	" Western species	....	....	....	....	....	....	....	....	....
57	Night Hawk, Eastern species	....	147	....	139	....	....	....	....	....
58	" " Western species	....	....	....	....	....	....	....	....	....
59	Wild Ducks, first birds	....	....	....	....	....	....	101	....	....
60	" " " Flocks	....	....	....	....	....	....	....	....	....
61	" " last Flock	....	....	....	298	....	....	....	....	....
62	" " " Birds	....	....	....	....	....	....	....	....	....
63	Wild Geese, first Birds	....	92	....	93	....	....	....	....	....
64	" " " Flock	....	....	....	....	....	....	78	....	....
65	" " last Flock	....	....	....	....	....	....	....	....	....
66	" " " Birds	....	....	....	346	....	....	....	....	....
67	Frogs piping, first date	....	107	108	106	....	....	105	110	....

* Winters in.

TABLE B.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, 1896.

Number.	Wallace, N. S.	Pictou (M), N. S.	Pictou (R), N. S.	New Glasgow, N. S.	Antigonish, N. S.	Port Hawkesbury, N. S.	Average Southern Nova Scotia.	Charlottetown, P.E.I.	Saint John, N. B.	Richibucto, N. B.	Niagara Falls, O.	Muskoka, O.	Reston, Man.	Pheasant Forks, Assa.	Vancouver, B. C.
31	...	...	...	...	125	...	...	127	...	127	...	...	114	126	...
32	...	...	...	...	...	...	...	...	...	...	...	...	191	...	...
33	...	...	...	237	...	...	...	227	...	221	...	...	221	...	...
34	166	...	...	...	165	176	162·7	144	...	159	113	...	137	...	...
35	281	...	...	...	249	239	259·2	266	...	275	266	248	...	215	...
36	...	...	...	...	...	118	...	...	...	...	...	...	...	...	...
37	...	...	...	...	329	353	341·0	...	...	...	...	...	...	...	...
38	...	...	...	...	72	...	...	101	...	109	89	...	106	95	...
39	357	...	...	...	...	...	...	356	...	336	...	...	309	295	...
40	110	...	...	...	...	111	...	110	...	109	89	107	126	98	...
	133	...	...	...	...	139	...	111	...	...	109	...	129	...	...
	169	...	...	...	...	...	...	131	...	...	113	146	132	145	...
	173	...	...	...	...	172	...	174	...	156	128	157	137	158	...
	174	...	...	...	...	...	...	185	...	170	136	159	162	169	...
	180	...	...	...	...	...	...	192	...	174	138	...	166	...	...
	194	...	...	...	...	...	...	194	...	194	148	...	168	...	...
	197	...	...	...	...	197	...	197	...	197	158	...	169	...	...
	203	...	...	...	...	...	...	...	...	...	160	...	174	...	...
	213	...	...	...	...	215	...	208	...	...	...	...	178	...	...
	217	...	...	...	...	232	...	217	...	217	...	...	186	215	...
	222	...	...	...	...	242	...	225	...	222	...	...	190	...	...
	225	...	...	...	...	250	...	...	...	249	...	...	198	...	...
	251	...	...	...	...	260	...	...	...	...	...	...	214	...	...
	263	...	...	...	...	263	...	...	...	...	...	...	217	...	...
	...	...	...	...	...	279	...	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	...	...	303	...	...	...
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	...	...	323	...	...	...
41	...	...	...	...	...	...	...	...	...	...	...	...	178 to 198	...	...
42	...	...	...	...	...	101	...	101	...	...	88	...	...	...	...
44	...	...	...	99	...	97	...	102	...	106	88	95	...	...	...
45	...	...	...	...	...	...	...	...	...	...	89	...	119	105	...
48	...	...	...	...	...	...	...	101	...	...	...	...	...	...	...
49	...	...	...	...	...	...	...	...	...	...	...	...	291	...	...
50	...	...	...	...	...	...	...	...	...	...	88	...	114	105	...
51	...	...	...	...	...	...	...	...	...	...	104	...	...	...	...
52	116	...	...	...	...	130	...	137	...	116	105	...	135	...	...
53	...	...	...	...	...	...	...	...	...	...	94	...	97	108	...
54	...	...	...	...	...	124	...	...	...	116	103	...	...	...	...
55	139	...	...	138	...	141	...	...	...	138	140	121	...	...	...
56	...	...	...	...	...	...	...	...	...	...	140	...	...	...	...
57	...	...	...	...	...	177	...	179	...	...	...	141	...	149	...
58	...	...	...	...	...	...	...	...	...	...	...	...	134	...	...
59	...	...	...	...	...	*	...	...	...	...	88	...	104	87	...
60	...	...	...	...	...	...	...	91	...	...	88	...	111	106	...
61	...	...	...	...	...	264	...	...	...	...	...	...	...	...	...
62	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
63	67	75	...	...	...	...	...	...	...	...	87	118	87	87	...
64	68	...	...	...	...	80	...	98	...	87	87	...	94	98	...
65	252	...	...	...	...	298	...	271	...	...	...	317	...	...	...
66	340	...	...	...	...	...	...	...	...	...	...	...	...	...	...
67	103	103	103	...	107	111	...	105	...	116	105	104	112	115	50

MEAN OF TWENTY PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, FOR THE FIVE YEARS, 1892 TO 1896.

Species common to the Tables of the five years.		Average Date 1892.	Average Date 1893.	Average Date 1894.	Average Date 1895.	Average Date 1896.	Five Year Mean.	Normal date of first flowering, etc.
Mayflower,	first flowering	98	108	104·7	113·55	102·70	104·79	5th April.
Alder,	" "	102	114	116·3	103·8	107·55	108·73	9th "
Aspen,	" "	131	123	122·2	117·5	121·90	123·12	4th May.
Maple,	" "	123	130	126·3	123·85	124·55	125·54	6th "
Strawberry,	" "	129	133	131·6	128·55	128·50	130·13	11th "
Dog-tooth V.,	" "	135	136	132·2	125·	128·50	131·34	12th "
Cherry (Cult),	" "	146	142	146·3	136·6	143·00	142·78	23rd "
Indian Pear,	" "	145	144	146·	138·35	141·65	143·	24th "
Cherry (wild),	" "	150	144	147·	138·15	145·25	144·88	25th "
Apple,	" "	146	146	152·1	166·65	151·10	152·37	2nd June.
Lilac,	" "	154	160	162·3	153·5	160·50	158·06	8th "
Hawthorn,	" "	163	160	160·3	148·75	160·25	158·46	8th "
Wild Goose,	first........	54	88	70·6	78·00	80·00	74·12	6th March
Robin,	"	96	94	73·2	99·30	96·14	91·73	2nd April.
Song Sparrow,	"	99	115	79·	96·65	94·66	96·86	7th "
Frogs piping,	"	105	113	112·8	110·55	106·30	109·53	10th "
Swallow,	"	106	119	119·	125·75	117·76	117·50	18th "
Kingfisher,	"	128	137	128·7	127·50	122·00	128·64	9th May.
Humming Bird,	"	143	159	143·0	137·25	139·30	144·31	25th "
Night Hawk,	"	150	144	158·8	148·00	154·33	151·03	1st June.

V.—SUPPLEMENTARY NOTE ON VENUS.—BY A. CAMERON, *Yarmouth, N. S.*

(Read 10th May, 1897.)

In the Transactions of this Institute for 1892-3, (Second Series, Vol. I., Part 3), there is an article of mine on "Venus in Daylight to Eye and to Opera Glass." On page 345, the late M. Trouvelot of the Observatory at Meudon, is quoted to the effect that in a clear sky Venus may be seen in daylight with the naked eye, when her angular distance from the sun is not less than 10° at inferior conjunction, and not less than 5° at superior conjunction.

On pages 347-8 particulars are given of a naked eye observation made at noon on July 6, 1892, when the angular distance between Venus and the Sun was less than 7°. This was a little over three days before inferior conjunction. Three of these conjunctions have occurred since then—in February, 1894, September, 1895 and April, 1897—but, so far as I know, no closer observation was got at any of them. On the morning of February 14th, 1894, I saw Venus with naked eye, when less than two days before inferior conjunction; but this was not a "daylight" observation as defined in the article cited; and, besides, the elongation was more than 7°. This observation was one of a pair, which, as a pair, had some rather curious features. (See Series II., Vol. I., pp. 391-4.)

The chief purpose of this note is to make a few additions to what was said in the Daylight article about observations made near superior conjunction. M. Trouvelot thought that Venus should be as easy to the naked eye in full daylight, when only 5° from superior conjunction as when 10° from inferior conjunction. My reasons for thinking so too are given on pages 349-52. But when writing that article, the best reliable observation of this kind I had been able to make near any superior conjunction was made thirty-six days after the one in May, 1893, when the elongation was 10°. (p. 351.)

There have been two superior conjunctions since then, and at each of them a better observation than the above was made.

At Denver, Colorado, on October 30th, 1894, Mr. Roger Sprague saw Venus with the naked eye at 9.45 a. m. This was thirty-one days before the superior conjunction of November 30th. 1894. The angular distance was 7° 46′. Mr. Sprague says that the planet was "quite a difficult object to distinguish with the naked eye and required very persistent and careful looking to make it out at all." The difficulty of his observation led him to doubt the possibility of seeing Venus at all under the conditions that prevailed on July 6, 1892, Venus was five times as bright to him in October, 1894, as to me in July, 1892; she was nearly a degree farther from the sun; and Denver is 5000 feet nearer heaven and is blessed with a clearer atmosphere than Yarmouth. As the feat of seeing the planet was found extremely difficult under this fourfold set of favorable conditions, it was quite natural for the observer to think it impossible under the unfavorable conditions. I would think so too, had I not had experience of its possibility, and of the wonderful change that even a few minutes sometimes make in the seeing quality of the atmosphere or in the clearness of some particular patch of the sky. The clearest and purest blue is found between broken masses of cloud, and it was in such a swept and garnished bit of sky that I found Venus at her inferior conjunction in 1892. Another thing—she was 28° nearer my zenith then than she was to Mr. Sprague's zenith when he made his observation, and all observers know what a deal of difference that makes. Had he looked again an hour and a half later, when she was on his meridian, he would probably have found her—if his sky was clear—absurdly easy instead of extremely difficult.

Mr. Sprague's observation was the best one near superior conjunction that I had any record of up to that date.

The date of the next superior conjunction was July 9, 1896, at 9 a. m., 60° W. time.

To better the record, it was necessary to see Venus when less than thirty-one days from that date, and less than 7¾° from the sun.

The thirty-first day before conjunction was June 8th. The midday sky was cloudy then, and so it was on the 9th, 10th, and 11th. On the 12th we had the pure blue sky that follows summer rain, and at noon my naked eye found Venus "disgracefully easy." So my notes say. I suppose they mean it would have been disgraceful for even a bad eye (as was one of the two that made the observation) not to see her. They go on :—"Eye holds her dodging through clouds, and picks her up over and over again." This was twenty-seven days before conjunction. On the 13th, she was easier than on the 12th. Then there were nine days unfit for observation. On the 23rd, we had another of those glorious skies that follow a spell of rain and fog, and Venus was again easy, and was found very quickly after being located by a field-glass. On the 24th, she was not so easy, because the sky was white. On the 25th, the sky was fine, and my naked eye saw her for the last time before conjunction. It was fourteen days before, and the angular distance from the sun's centre was under 4°.

All the observations from June 12th to June 25th, were made between 12 and 12.30, (60° W. time), when Venus was very near the meridian, As the conjunction was a July one like the inferior conjunction of 1892—the very same day, indeed, July 9, in both cases—I had the advantage of high altitude.

This is likely my last note on this subject, and it may be as well to set down here a summary of the extreme observations which I have managed to make on Venus both with the naked eye and with an opera-glsss. A description of the glasses I used is given in the article cited, p. 354.

With naked eye :—

(*a*) At inferior conjunction—3 days before the conjunction of July 9, 1892. Elongation 6° 50′ from sun's centre. Altitude 64°.

(*b*) At superior conjunction,—14 days before the conjunction of July 9, 1896. Altitude 70°. Elongation, 3° 51′ from centre, 3° 35′ from limb.

Both of these observations were made within 15 minutes of mean noon.

(*c*) Near greatest elongation or greatest brilliancy,—April 30, 1892: found by eye when 18° above east horizon, the sun at the time being 44° high.

Angust 23, 1892: held by eye till only 8° above W. horizon, sun being over 35° high.

(Then there is the curious pair of observations already referred to—one after sunset on February 13, 1894, the other on the following morning before sunrise.)

With opera-glass or field-glass :—

(*a*) At inferior conjunction,—July 9, 1892: on the day and at the hour of conjunction. Elongation 4½°. Altitude 64°.

(*b*) At superior conjunction,—May, 11, 1893: 9 days after conjunction. Elongation 2¼° from limb. Altitude 64°.

December 12, 1894: 16 days after conjunction. Elongation 3¾°. Altitude 22.°

(*c*) Near greatest elongation or greatest brilliancy,—March 28, 1892: found when 7½° above East horizon. Sun's altitude 24½°.

August 23, 1892 : held till only 3° above West horizon. Sun's altitude 29°.

YARMOUTH, N. S., *April 30, 1897.*

VI.—THE RAINFALL IN 1896. BY F. W. W. DOANE, M. CAN. SOC. C. E. CITY ENGINEER, *Halifax, N. S.*

(Read 10th May, 1897.)

The systematic and accurate registration of the rainfall is a matter of the greatest importance to the Engineer. It is absolutely necessary in order to enable him to design intelligently works for water supply, sewerage, water power, drainage of roads, bridges, culverts, &c.

He requires certain data to enable him to design dams spillways, storage reservoirs, sewers, bridges, &c., so that every possible requirement may be provided for.

The quantity of rain that falls annually in any one place varies greatly from year to year; the extreme being sometimes greater than 2 to 1. As a general rule, more rain falls in warm than in cold countries, and more in elevated regions than in low ones. Local peculiarities and conditions, however, sometimes reverse this, and also cause great difference in the amount in places quite near each other. It is sometimes difficult to account for these variations.

The earliest known records of rainfall were made in Paris in 1668. Sir Christopher Wren designed the first rain gauge in 1663. This great architect also designed the first recording gauge, but it was not constructed until 1670.

The rainfall records of some portions of the United States cover periods extending into the last century. In Canada, the average amount of rain falling in Ontario has been taken by the officials of the Magnetic Observatory at Toronto for the past 56 years. The meteorological station at Halifax was established in 1869, and observations began at Truro in 1873; a systematic registration of rainfall has been made at Yarmouth since 1879, and the record at Sydney dates back to 1893.

An examination of the records of the United States reveals some interesting and important facts, which it may be well to quote at this stage for the purpose of comparison.

The greatest annual rainfall on this continent is recorded at Greytown, the Atlantic entrance to the proposed Nicaragua Canal. It there assumes the enormous total of 240 inches (20 ft.), a figure which is only surpassed in the Western Hemisphere on the Mexican Gulf Coast in the West Indies, by Guiana and by the coast of Brazil. It is reported that from 7 to 10 per cent. of the total annual rainfall may descend in one day. The results of such a precipitation can be better imagined than described; dry river beds become torrents in a few minutes, the water coming down in a wall several feet high; marshes change to lakes, and the power so quickly developed is necessarily very dangerous to any work of man.

The most remarkable rainfall is recorded at Cuyamaca Dam in San Diego Co., California, about 40 miles east of San Diego. During a storm ending February 27, 1891, the record shows that 23.40 inches fell in 54 hours, of which 13 inches fell in 23 hours, and 7 inches in 10 hours. The elevation of the reservoir is about 4500 feet above sea level. The highest surrounding mountains are 6500 feet above sea level, and lie to the west of the reservoir between its watershed and the direction whence the storms come. The eastern boundary of the basin is on the rim of the desert at an elevation of not over 5000 ft. The topography of the country is such that a rain gauge at the dam would not be likely to indicate the maximum precipitation on the three peaks that bound the water shed on the west. The most notable thing about the above remarkable rainfall, however, is that the place where it occurred is within a few miles of one of the very driest regions in the world. The average annual rainfall at Indio, San Diego Co., a station on the Southern Pacific Railway, about 50 miles east of the Cuyamaca Dam, is given by General Greely as but 1.92 inches, and he says of this and Camp Mohave, Arizona, where the average rainfall is but 1.85 inches: "These stations, doubtless, have the smallest known rainfall on the face of the globe. Statements have been made frequently that rain never falls in these localities, but there is no year at any station where a measurable rainfall has not been recorded, the least observed being that at Indio, 0.10 in., during the seasonal year 1884-85."

General Greely's "American Weather" gives the following instances of heavy rainfalls, which exceed the above record: Mayport, Fla., Sept. 29, 1882, 13.7 ins. in 24 hours; Newtown, Del. Co., Pa., Aug. 5, 1843, 13 in. in 3 hours; and at Brandywine, Hundred, Pa., 10 ins. in 2 hours.

Nevada Co., California, reports the rainfall for the month from Dec. 23, 1861, to Jan. 23, 1862, 45 ins. Providence, R. I., records a rainfall Aug. 6, 1878, 4.49 ins. in 1 hour, 3.5 ins. of which fell in 36 minutes. At New York, the heaviest fall is Aug. 19, 1893, 1½ ins. in 20 minutes; for 12 hours Aug. 23, 1893, 3.81 ins.; 24 hours Sept. 23-4, 1882, 6.17 ins.; month Sept., 1882, 14.51 ins.

The average annual rainfall at Halifax from 1869 to 1895 was 55.862 inches. It varies from 45.808 ins. in 1894 to 66.294 inches in 1888. A rainfall of 39.51 inches is reported for 1860, but as the Meteorological Observatory had not been established at that time, it is doubtful if the record is reliable. There is no doubt, however, that the rainfall for that year was far below the average. The scarcity of water, meagre supply from the lakes, and consequent inconvenience to householders lead to the purchase of the water works from the company in the following year, 1861.

Reference to the records shows that the years of smallest rainfall are immediately followed or preceded by years of greatest rainfall. Thus in 1888 the rainfall reached the maximum 66.294 inches. In the following year it dropped to 48.659, within 2.851 inches of the minimum. In 1894, as already noted, the season was very dry. The rainfall was the smallest recorded since the establishment of the Observatory at Halifax. The sources of our water supply dried up so that there was danger of a water famine. Similar conditions were noted throughout the New

England States. In the following year the records show a total of 62.152 inches, while in 1896 Mr. Allison, Dom. Government Meterological agent at Halifax, reports 69.862 inches, 3.568 ins. greater than that of any previous year. Rain or snow fell on 183 days. The greatest monthly rainfall on record previous to 1896 was 10.34 in February, 1870. In 1888 the heaviest monthly fall was 7.764, which is recorded in December. In 1896, 8.729 ins. fell in July, and 8.786 inches in March, while in September and October, the record shows 12.092 inches and 15.039 inches, respectively. Rain fell on 16 days in September, and on 20 days in October. The fall on the 7th, 10th, 13th and 18th of September, was 1.232 ins., 3.912 ins., 3.146 ins., and 1.510 inches, a total for the four days of 9.8 ins., or more than $\frac{3}{4}$ of the whole precipitation for the month. In October, 4.394 ins. fell on the 19th, 29 per cent. of the rainfall for the month, and 6 per cent. of the total for the year. The first month, January, gave the modest total of 1.72 inches, while for January, 1895, 10.131 inches is recorded.

There were four heavy storms during the year. Early in the morning of July 31st, rain began to fall, and during 3.8 hours the gauge showed 3.506 inches, or at the rate of .92 inches per hour. The rate of fall was the heaviest on record, although the quantity was exceeded in subsequent storms of greater duration.

On Sept. 10th, rain fell during 7.5 hours, the quantity registered being 3.912 ins., or at the rate of .52 ins. per hour, 0.186 inches fell on the 11th during 4.1 hours, 0.13 ins. on the 12th during 2 hours, and on the 13th, 3.146 ins. fell during 9.5 hours, or at the rate of .33 ins. per hour. The total fall for the four days was 7.374 inches. On October 19th the maximum quantity was recorded, the precipitation being 4.394 inches during 14.3 hours, or at the rate of .30 inches per hour.

The September rains referred to above raised Long Lake about 32 inches, the highest level reached being 10.5 inches above the waste weir. In October, the ground was saturated with water, and the rain falling on the 19th flowed off rapidly. Long Lake was raised 20 inches by the heavy storm of the 19th in about 24 hours. The water level was 25 inches above the spillway of the dam, while at Lower Chain Lake it overflowed the screen chambers and ran over the floor of the old gate house. Drains and culverts were destroyed, roads washed out and bridges carried away. Jubilee Road was excavated by the rush of water for a length of 100 yards, the road metal being carried away for a width of half the roadway and a depth of 6 ft. Heavy stones were deposited at the foot of the hill, while the lighter material went to sea. The main trunk sewer on the common was not only full to overflowing, but a torrent of water followed its course on the surface, sweeping through the gardens and down South Park Street, until it found an outlet at South Street.

The Meteorological Agent at Truro reports about 30 hours rain on the 18th and 19th October, the greatest on record with regard to duration. At Yarmouth and Sydney the rain fall was light.

September 10th-13th, Sydney reports no rain ; Yarmouth and Truro comparatively light rains. July 31st, moderate rainfall at Sydney, Truro and Yarmouth.

Comparing the Halifax records by months we find :—

July, 1896, 8.729 ins.—next—July, 1884, 8.294 ins.
Sept., 1896, 12.092 " " Sept. 1876, 6.094 "
Oct., 1896, 15.039 " " Oct., 1875, 9.98 "

Mr. E. H. Keating, City Engineer, says in making his report on a design for the Halifax sewer system :—

"The heaviest rainfall in a short time, of which I have any information, occurred on the 19th June, 1872, when 0.183 of an inch fell in half an hour."

He also reports a rainfall of 4.406 inches in 18 hours on the 10th October, 1875.

Our sewer system was designed to discharge a rainfall of 0.38 ins. per hour, together with the house sewage when running two-thirds full. The designer made a liberal estimate in determining the capacity required, and yet during the past year it was plainly demonstrated that the capacity of the sewers was not sufficient to carry off the rainfall, and great trouble, damage and inconvenience has been caused in consequence. There is not the slightest doubt that the greater part, if not the whole, of this trouble would have been obviated if records of self-recording rain gauges had been available. While the greatest rainfall on record in 1876 was .183 inches in half an hour, we had in 1896 a storm lasting 7.5 hours, with an average rate of fall of .52 inches per hour, and another lasting 3.8 hours, with an average fall of .92 inches per hour. The maximum rate must have been greatly in excess of even the latter figure, but as the storm came n the dark hours of the morning, and the rain was not measured by self-registering instruments, we can only guess at the maximum rate per hour.

The design of sewers depends principally on two classes of storms. These are short storms of great rates of precipitation, and long storms of ordinary rates of precipitation. It is not sufficient to know the rainfall per hour. The severity of a storm often reaches a maximum during from 10 to 20 minutes only, and this maximum should be determined, if possible. It is also most important that the local conditions of the surface should be known. If the ground is saturated before the storm the rainfall will run off more rapidly.

A chief purpose to be subserved by a rainfall record is not merely how often does the maximum rainfall occur at each point, for that is an event which only occurs once or twice in a century. The great desideratum is: How often do the heaviest rainfalls of various rates occur, and for how long a maximum and average time does such a rainfall continue? The records from which such laws are deduced must necessarily be somewhat voluminous, and yet by proper study, aided by records of a number of years, a very close approximation to the real probabilities could be obtained and drawn graphically on charts, which would be of the greatest aid to hydraulic and city engineers; and even without this, the bare records would give to a man who might be designing works at special points, material for digging out for himself some approach to a law where now all is guess work, and often very bad guess work.

It is to be regretted that the Meteorological Stations in this Province are not supplied with the most modern self-recording instruments. With an ordinary rain gauge it is not possible to determine the rate per hour of the fall of rain during a storm, without noting the time with a watch; and as it is very inconvenient, if not impracticable in the majority of cases to do this, it is very rarely done, and when it is, an average rate is all that is generally ascertained, although it may have been raining faster or slower at intervals during the time noted. By the use of a reliable self-recording rain gauge the different rates at which rain has fallen during a storm can be readily determined.

DEPTH OF RAINFALL AND MELTED SNOW, AND DURATION OF EACH STORM, FOR THE YEAR 1896.

Day of Month.	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.
1	......	....	......	....	......	....	......	....	......	....	0.180	1.5
2	......	....	0.440	20.	0.089	7.2	......	....	......	....	0.020	....
3	0.065	1.75	*T.	....	0.094	3.5	0.889	5.6	......	....	......	....
4	......	....	......	....	0.510	6.7	0.015	1.	......	....	......	....
5	......	....	......	....	0.186	4.	0.323	6.5	0.106	2.0	......	....
6	......	....	T.	....	......	....	0.012	0.5	0.050	2.0	0.020	0.5
7	......	....	1.310	14.	0.030	1.6	......	....	......	....	......	....
8	......	....	......	....	0.596	7.	......	....	....	....	......	....
9	....	....	0.010	1.	......	....	......	....	T	....	0.770	10.1
10	0.660	10.5	0.342	6.5	......	...	......	....	T.	....	0.970	11.3
11	0.030	2.5	0.480	3.	0.030	1.1	.....	....	....	....	0.090	2.3
12	......	....	0.100	1.	1.619	15.	......	....	0.130	0.5	0.444	8.5
13	0.040	1.5	0.020	1.7	......	....	......	....	.....	....	......	....
14	0.140	4.66	0.522	7.75	.....	....	0.009	1.0	.....	....	T.	....
15	T.	....	......	....	......	....	0.034	2.0	......	....	0.841	14.5
16	0.020	10.	0.260	6.5	0.040	2.	T.	....	......	....	0.086	3.
17	.....	....	......	....	1.655	13.5	0.040	2.5	......	....	......	....
18	......	....	0.010	1.	.....	....	0.015	2.0	0.250	1.0	0.010	0.5
19	.....	....	0.220	5.2	0.020	0.8	0.020	0.8	0.068	3.0	......	....
20	......	....	0.410	8.3	1.498	9.4	0.010	1.0	0 210	3.5	0.050	1.5
21	......	....	......	....	......	....	......	....	......	....	......	....
22	0.050	7.5	......	....	......	....	..	....	0.305	5.8	0.060	1.7
23	......	....	......	...	......	....	......	....	0.186	0.5	......	..
24	......	....	0.075	2.	......	....	......	....	....	....	......	....
25	0.390	10.	......	....	......	....	......	....	......	....	.....	....
26	0.270	12.5	......	....	0.192	1.7	......	...	......	....	0.230	4.0
27	0.045	1.75	.....	....	1.450	8.5	......	....	0.247	3.0	0.200	3.7
28	0.010	....	.....	....	......	....	.....	....	0.014	....	......	....
29	......	....	......	....	......	....	0.046	..	0.540	2.7	0.700	8.3
30	......	....	......	....	0.274	8.2	......	....	0.426	6.0	......	....
31	......	....	......	..	0.503	7.3	.. ..	....	......	....	......	....
	1.720	....	4.199	....	8.786	....	1.413	....	2.532	...	4.671	....

* Trace.

DEPTH OF RAINFALL AND MELTED SNOW, AND DURATION OF EACH STORM, FOR THE YEAR 1896.

Day of Month.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.
1	.....	....	......	....	.....	....	2.352	10 4	0.005	0.4	0.020	0.5
2	.....	....	0.354	5.0	......	....	0.764	9.5	0.170	6.6	......	....
3	....	....	0.378	5.0	......	....	0.552	8.7	0.032	1.0	.....	....
4	T.	....	.....	....	0.112	3 8	0 010	1.5	.....	....	T.	....
5	0.938	11.0	......	....	......	....	.....	....	...	....	0.362	5.3
6	......	....	......	....	......	....	0 685	11.2	0.824	10.1	...	....
7	0.664	6.0	0.102	8.0	1.232	12.5	0.312	24.	T.	....	......	....
8	0.306	3.0	0.010	1.0	0.030	1.0	0.230	6.5	......	....	......	...
9	......	....	......	....	...	....	.....	....	0.853	6.5	1.524	13.3
10	......	....	0 010	....	3.912	7.5	.....	....	0.036	0 3	0.020	0.8
11	....	....	......	....	0.186	4.1	......	..	0.033	2.0	T.	....
12	.....	...	T.	....	0.130	2.0	......	....	0.682	5.5	......	....
13	......	....	T.	...	3.146	9.5	0.756	10 0	T.	....	0.020	1.0
14	0.170	3.3	T.	....	......	...	1.597	12.2	0.207	7.3	......	....
15	0.062	1.2	.....	...	......	....	0.125	12.0	T.	....	.....	..
16	0.220	5.0	0.250	5.5	......	....	0.022	6.1	0.071	3.0	0 450	9 7
17	T.	....	0.082	3.0	0.302	4.0	......	....	.....	....	0.150	2.5
18	.....	....	......	...	1.510	4.5	0 823	10.4	......	....	.....	....
19	......	...	0.034	1.7	0.546	4.5	4.394	14.3	0.020	1.5	0.692	8.0
20	.....	....	0.060	0.9	0.507	...	......	....	.....	...	......	....
21	0.670	11.0	.....	....	T.	...	......	....	0.010	0.1	......	....
22	......	....	......	....	0.041	1.5	0.372	5.2	0.732	7.5	......	....
23	1.041	12.8	......	....	0.405	5.8	....	....	....	....	......	....
24	.....	....	1.372	8.4	.....	....	0.562	6.0	0.178	9.4	...	....
25	0.568	8.0	......	....	......	....	1.007	8.0	.....	....	......	....
26	.....	....	......	....	......	....	.....	....	0.130	13 0	0.010	3.2
27	.....	....	0.333	5.4	......	....	0.010	0.4	0.121	6.3	.....	....
28	0.584	7.0	0.052	3.8	0.033	0.2	......	....	......	....	......	....
29	.....	...	....	....	......	....	0.109	3.0	0 202	6 3	...	....
30	....	....	.....	....	T.	....	0.227	18.2	0.090	5 0	....	....
31	3.506	3.8	T.	..	..	....	0.130	4.1	......	....	T.	....
	8.729	....	3.037	....	12.092	....	15.039	....	4.396	....	3.248	...

TOTAL PRECIPITATION AT HALIFAX, N. S.

Compiled from Returns furnished by the Meteorological Agent of the Dominion Government.

MONTH.	1869.	1870	1871.	1872.	1873.	1874	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
January	4 53	7.11	3 73	3.88	7.83	5.42	3.94	3.576	4 200	7.534	4 400	7.738	3.607	6.840
February	4 38	10.34	5.88	4.49	1.61	5.31	5.83	6.401	1.809	2.697	3.001	5 122	5.329	5.949
March	7.95	3.02	6.16	5 37	4 09	3.98	2.13	6.329	8.666	10.274	6.044	3.365	6 556	7.068
April	2.57	3.91	4 88	2.85	2 86	4.55	3 38	3.208	3.801	3.452	3.481	4 797	3 498	4.824
May..............	5.57	3.19	2 59	4.44	2.34	4.77	3.98	5 662	4.024	5.769	4.687	4.088	2.460	4.677
June	3 92	1.69	2.96	4 23	2 96	7.92	4.07	3 376	3 841	4 477	1.191	1.343	5 301	5.507
July..............	2.92	3 21	3.38	2.88	3.90	2.29	5.61	3.914	4.468	1.483	3.843	3.086	3.177	5.071
August	2.58	2 20	3 69	6.82	4.45	3.37	3 55	1.909	3.539	3.127	4.827	3.920	3.062	3 925
September	1.57	3.33	4.81	1 41	4.48	5.04	2.06	6.094	3.164	.800	2.600	5.702	3 105	5.914
October	7.30	6.85	4.49	4.88	8 63	2.46	9.98	4 076	6.857	5.060	4.760	4.590	4.206	7.403
November	5.47	6.28	4.18	6 65	7.98	3.58	5.54	7.397	8.678	6 909	4 837	4.710	4.420	1.392
December	5.77	6.06	4.39	6.16	4 31	5.49	1.61	3.164	4.493	5.120	4.029	4 291	7.034	3.452
Totals	54.53	57.19	51 14	54.06	55.44	54.18	51 48	55.106	57.540	56 702	47.700	52.752	51.755	62.022

TOTAL PRECIPITATION AT HALIFAX, N. S.—*(Continued)*.

MONTH.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January	6.930	4.406	6.388	8.67	7.656	5.442	4.391	3.963	8.383	6.321	4.781	7.122	10.131	1.720
February	3.860	6.161	5 090	3.84	6.735	6.284	6.181	4.645	8 740	2.605	5.979	3.571	4.605	4.199
March	4.941	7.034	3.889	4.03	4.629	4.310	2.046	9 889	2 685	5.986	2.303	3.623	5.931	8.786
April	3.703	7.213	3.520	0.82	6.386	3.675	7.403	2 958	4.010	2 653	4 209	5 648	3.956	1.413
May..........	8.613	3.629	3.282	8.82	2.126	2.877	3.871	3 970	4.195	5.459	5 054	1.769	4.089	2.532
June.	3.322	3.773	2.749	2.71	2.121	4.939	3.755	3 440	4.131	3.638	1.753	3.803	1.827	4.671
July..........	3.542	8.294	5.817	6.53	2.045	5.001	2.668	2.141	4.003	2.710	4.757	1.059	3.924	8.729
August	5.342	2.771	3.001	4.53	8.351	7.000	2 633	7.042	3 385	6.809	5.954	3.993	5.502	3.037
September	3.864	1.788	2.497	4.46	3.308	5.331	1.399	4.534	3 052	1.744	4.391	1.010	2.491	12.092
October	5 841	3.093	6.280	2.13	3.058	6 859	4.179	6.603	9 621	3.492	5.640	3 863	5.627	15.039
November	5.478	5.992	5.423	5.28	6 718	6.772	7.145	3.716	2.388	9.240	3.760	5.785	8 223	4.396
December	6.678	9.124	8.693	5.47	4.120	7.764	2.988	7.202	4.076	3 053	10.167	4.562	5.846	3 248
Totals	58.112	63.278	56.629	57.29	57.253	66.294	48.659	60 103	58.669	53.690	58.748	45.808	62.152	69 862

PRECIPITATION AT TRURO IN 1896.

MONTH.	Rainfall	Melted Snow.	TOTAL.
January	0 07	2.3	2.37 inches.
February	0.12	1.5	1.62 "
March	4.11	1.0	5 11 "
April	0.60	0 5	1.10 "
May	1.45	....	1.45 "
June	3.44	....	3.44 "
July	6 19	....	6.19 "
August	2.24	....	2 24 "
September	5 01	....	5.01 "
October	11 47	....	11.47 "
November	2.58	0 62	3.20 "
December	1.49	0.65	2.14 "
Totals	38.77	6 57	45.34 inches.
July 31	0.44	....	
Sept. 10-11	0 33	....	
" 13	0.35	....	
Oct. 1-3	4 65	....	
" 18-19	4 02	....	
Average rainfall for October, for 23 years	4 51	....	
Average precipitation for 17 years.	43.85	....	

PRECIPITATION AT YARMOUTH.

July 19-25, 1896	2.02
" 30-31, "	0.58
Aug. 23-24, "	2.45
Sept. 6-7, "	0.91
" 13-14, "	0.48
Oct. 1-2, "	0.12
" 18-19, "	0 04
" 23-24, "	1.97

Heaviest recorded rain, 4.16 inches, August 5th, 1885, in 8 hours.
Greatest precipitation in a month, 10.7 inches, October, 1888.
Total in 1888, 71 57 inches, 22.5 above the average.

PRECIPITATION AT SYDNEY.

July 31, 1896	0.60
Sept. 10, "	0 00
" 13, "	0.00
Oct. 1, "	1.76
" 19, "	0.54

Heaviest rain on record, 2.04 inches, August 17th, 1893.

Date of publication of Vol. IX, Part 3: November 30th, 1897.

APPENDIX.—III.

LIST OF MEMBERS, 1896-97.

ORDINARY MEMBERS.

	Date of Admission.
Allison, Augustus, Halifax	Feb. 15, 1869
Anderson, James F., Darmouth, N. S.	Jan 2, 1894
Austen, James H., Crown Lands Department, Halifax	Jan. 2, 1894
Bayer, Rufus, Halifax	March 4, 1890
Bennett, Joseph	Nov. 3, 1886
Bishop, Watson L., Dartmouth, N. S.	Jan. 6, 1890
Bliss, Donald M., Boston, U. S. A	Jan. 31, 1890
Bowman, Maynard, Public Analyst, Halifax	March 13, 1884
Brown, R. B., Yarmouth, N. S.	Jan. 10, 1891
Butler, Professor W. R., C. E., Royal Military College, Kingston, Ont	Nov. 27, 1889
Campbell, Donald A., M D , Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Clements, E. F., Yarmouth, N. S.	Jan. 10, 1891
Cowie, A. J., M. D., L. R. C. P. E , Halifax	Jan. 27, 1893
DesBrisay, A. E., Halifax	Jan. 4, 1891
DeWolfe, James R., M D., L. R. C. S. E., Halifax	Oct. 26, 1865
Dick, Alexander, M. E., Halifax	Nov. 29, 1894
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Point Tupper, Cape Breton	Nov. 30, 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Elliott, Miss Bertha	March 4, 1895
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
Finn, William D., M. D., Halifax	Oct. 29, 1894
Faville, E. E	Nov. 29, 1894
Forbes, John, Halifax	March 14, 1883
Foster, James G., Dartmouth, N. S.	March 14. 1883
Fraser, C. F., Principal, School for the Blind, Halifax	March 31, 1890
Fraser, Rev. W. M., B. A., B. SC., Halifax	Nov. 29, 1894
Fyshe, Thomas, Montreal	Jan. 9, 1888
Gilpin, Edwin, M.A., LL.D., F.R.S.C., Inspector of Mines, Halifax	April 11, 1873
Greer, T. A., M. D., Colborne, Ontario	April 7, 1893
Hall, Charles Frederick, Halifax	Dec. 31, 1894
Hare, Alfred A	Dec 12, 1881
Harris, Herbert, Vancouver, British Columbia	Jan. 31, 1880
Hattie, William Harop, M. D., Halifax	Nov. 12, 1892
Hendry, William A., Jr , C. E., Halifax	Jan. 4, 1892
Irving, G. W. T., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D., Halifax	May 8, 1894
Johnston, H. W., C. E., Halifax	Dec. 31, 1894
Keating, E. H., C. E., City Engineer, Toronto, Ontario	April 12, 1882
Kennedy, W. T., Principal, County Academy Halifax	Nov. 27, 1889

	Date of Admission.
Laing, Rev. Robert, Halifax	Jan. 11, 1885
Locke, Thomas J.	Jan. 4, 1892
McColl. Roderick, C. E., Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
MacGregor, Prof J. G., M. A., D SC., Dalhousie College, Halifax	Jan. 11, 1877
McInnes, Hector, LL.B., Halifax	Nov. 27, 1889
MacIntosh, Kenneth, Mabou, Cape Breton	Jan. 4, 1892
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
MacKay, A. H., B.A., B.SC., LL.D., F.R.S.C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH.D., Dalhousie College, Halifax	Nov. 27, 1889
McKerron, William, Halifax	Nov. 30, 1891
MacNab, William, Halifax	Jan. 31, 1890
Marshall, G. R , Principal, Richmond School, Halifax	April 4, 1894
Mason, F. H , F. C. S., Halifax	Dec. 31, 1894
Morrow, Arthur, M. D., Sand Coulee, Montana, U. S. A	Nov. 27, 1889
Morton, S. A., M. A., County Academy, Halifax	Jan. 27, 1893
Murphy, Martin, C. E., D SC., Provincial Engineer, Halifax	Jan. 15, 1870
Newman, C. L. Dartmouth, N. S	Jan. 27, 1893
O'Hearn, P., Principal, St. Patrick's Boys' School, Halifax	Jan. 16, 1890
*Parker, Hon. Daniel McN., M. D , M. L. C , Dartmouth, N. S	1871
Pearson, B F., Barrister, Halifax	March 31, 1890
Peter, Rev. Bro. J., La Salle Academy, Halifax	Dec. 3, 1896
Piers, Harry, Halifax	Nov. 2, 1888
Poole, Henry S., F. G. S., Stellarton, N. S	Nov. 11, 1879
Read, Herbert H., M. D., L. R. C. S., Halifax	Nov. 27, 1889
Ritchie, Thomas, C. E	Jan. 2, 1894
Robb, D. W,, M. E., Amherst, N. S	March 4, 1890
Rutherford, John, M. E., Stellarton, N. S	Jan. 8, 1865
Shine, Michael, Halifax	Dec 3, 1891
Silver, Arthur P., Halifax	Dec. 12, 1887
Silver, William C., Halifax	May 7, 1864
Smith, Capt. W. H., R. N. R., F. R. G. S., Halifax	Nov. 27, 1889
Somers, John, M. D., Halifax	Jan. 11, 1875
Spike, C. J., Halifax	May 8, 1894
Stewart, John, M. B. C. M., Halifax	Jan. 12, 1885
Tremaine, Harris S., Halifax	Jan. 2, 1894
Twining, Chas.. Bank of B. N A., Halifax	Dec. 3, 1896
Uniacke, Robert F., C. E	March 9, 1885
Weatherbe, Hon. Mr. Justice, Halifax	March 28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S	Nov. 29, 1894
Willis, C, E., M. E., Halifax	Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax	May 3, 1889
Yorston, W. G , C. E., Truro, N. S	Nov. 12, 1892

ASSOCIATE MEMBERS.

Caie, Robert, Yarmouth, N. S	Jan. 31, 1890
Calkin, Principal J. B., M. A., Normal School, Truro, N. S	Jan. 6, 1890
*Cameron, A., Principal of Academy, Yarmouth, N. S	Nov. 27, 1889
Coldwell, Prof. A. E., M. A., Acadia College, Wolfville, N. S	Nov. 27, 1889
DeWolfe, Melville G., Kentville, N. S	May 2, 1895
Dickenson, S. S., Superintendent, Commercial Cable Co., Hazelhill, Guysborongh Co., N. S.	March 4, 1895

---

* Life Member.

	Date of Admission.
Eaton, F. H., M. A	Jan. 6, 1890
Faribault, E. R., C. E., Ottawa, Ontario	March 6, 1888
Fox, John J., Montreal	May 8, 1882
Hardman, John E., M. E., Montreal	March 4, 1890
Harris, Prof. C., Royal Military College, Kingston, Ontario	Nov. 13. 1881
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B	Jan. 6, 1890
James, C. C., M. A., Dep Min. of Agriculture, Toronto, Ontario	Dec. 3, 1896
*Johns, Thomas W., Yarmouth, N. S	Nov. 27, 1889
Kennedy, Prof. Geo. T., M.A., D.SC., F G.S., King's College, Windsor, N.S.	Nov. 9, 1882
McKenzie, W. B., C. E., Moncton, N. B	March 31, 1882
Magee, W. H., PH.D., High School, Parrsboro', N. S	Nov. 29, 1894
Matheson, W. G., M. E, New Glasgow, N. S	Jan. 31, 1890
Patterson, Rev. George, D D, LL. D., New Glasgow, N. S.	March 12, 1878
Prest, W. H., Chester Basin, N. S	Nov. 29, 1894
*Reid, A. P., M D., L.R C.S., Supt. Victoria Gen Hospital, Halifax	Jan. 31, 1890
Rosborough, Rev. James, Musquodoboit Harbor, N. S	Nov. 29, 1894
Russell, Lee, B. S., Normal School, Truro, N. S	Dec. 3, 1896
Smith, Prof H. W., B. SC, Prov. Agricultural School, Truro, N. S	Jan. 6, 1890
Wilson, B C, Waverley, N. S	March 4, 1890

CORRESPONDING MEMBERS.

Ambrose, Rev. John, D. C. L., Herring Cove, N. S	Jan. 31, 1890
Ami, Henry M., D. SC., F. G. S,, Ottawa, Ontario	Jan. 2, 1892
Bailey, Prof. L. W, PH. D., LL D., F. R. S C., University of New Brunswick, Fredericton, N. B	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S	Nov. 29, 1871
Bethune, Rev. C. J. S., Port Hope, Ontario	
Dawson, Sir J. W, C. M. G., LL.D., F. R. S., Montreal	Jan. 31, 189
Duns, Prof. John, New College, Edinburgh, Scotland	Dec 30, 1887
Ells, R. W., LL.D., F.G.S.A, F.R.S C, Geological Survey, Ottawa, Ont.	Jan. 2, 1894
Fletcher, Jas., LL.D., F.L.S, F.R S.C., Entomologist and Botanist, Central Exp Farm, Ottawa, Ont	March 2, 1897
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario	March 3, 1891
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A	Jan. 6, 1890
Harrington, W. Hague, F.R.S.C., Post Office Department, Ottawa	May 5, 1896
Harvey, Rev. Moses, LL.D., F. R. S. C., St. John's, Newfoundland	Jan. 31, 1890
King, Major, R. A	Nov. 19, 1877
Litton, Robert T., F. G. S., Melbourne, Australia	May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F R. S	June 10, 1880
Marcou, Jules, Cambridge, U. S. A	Oct. 12, 1871
Matthew, G. F., M. A., F. R. S. C., St. John, N. B	Jan. 6, 1890
Maury, Rev. M., D. D, Ithaca, N. Y., U. S. A	Nov. 30, 1891
Prince, Prof. E E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario	Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A	March 31, 1890
Spencer, Prof. J. W., PH. D, F. G. S., Washington, D. C., U. S. A	Jan. 31, 1890
Trott, Capt., S. S. "Minia," Anglo-American Telegraph Co	Jan. 31, 1890
Waghorne, Rev. Arthur C, St. John's, Newfoundland	May 5, 1892
Weston, Thomas C., F.G S.A., Geological Survey, Ottawa, Ontario	May 12, 1877

---

* Life Member.

Stewart
Wallace
75¢